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JRB Associates, Inc., McLean, VA

Prepared for

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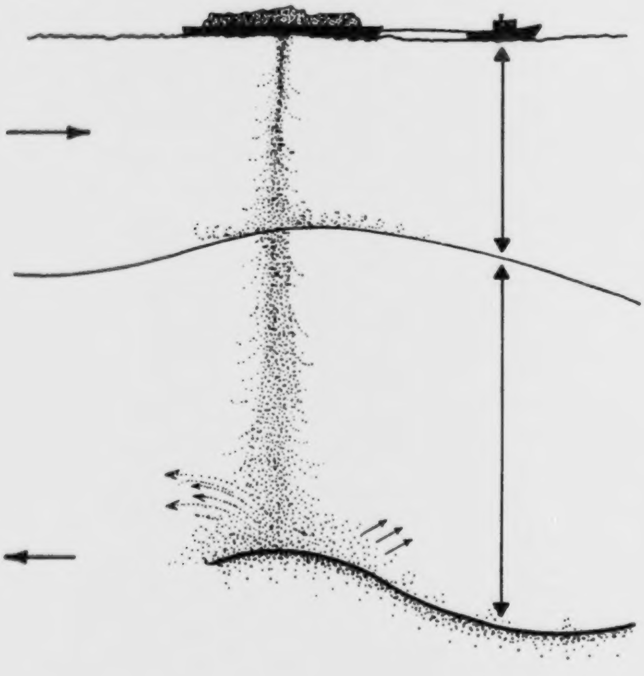
PROCEEDINGS OF A WORKSHOP FOR THE DEVELOPMENT OF A SCIENTIFIC PROTOCOL FOR OCEAN DUMP SITE DESIGNATION

W. Alton Jones Campus of the
University of Rhode Island
February 14-17, 1983

Prepared for

U.S. Environmental Protection Agency
Office of Water Regulations and Standards
Criteria and Standards Division
Washington, D.C. 20460



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The principal objective of the workshop was to develop a concensus, state-of-the-art protocol of the acquisition, organization, and interpretation of information for the purpose of ocean dump site designations. The principal criteria for the protocol were utility and scientific credibility. To ensure that the workshop discussions were well-focused, a "strawman" site designation protocol was developed to serve as an initial working document. This document was distributed for review to all attendees approximately one month prior to the workshop.

The workshop was organized into four different task groups, each corresponding to one of the principal components in the protocol. Time was divided between individual task group meetings and plenary meetings. These meetings were intensive working sessions. Attendees were asked to review, criticize, revise, and if necessary, re-formulate the "strawman" protocol. Each task group, under leadership of a group chairperson, was asked to produce a report summarizing their recommendations and documenting all of their discussions. Task group reports were presented at the final session of the workshop.

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W. Alton Jones Campus of the
University of Rhode Island
February 14-17, 1983

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Prepared for

U.S. Environmental Protection Agency
Office of Water Regulations and Standards
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Washington, D.C. 20460

DISCLAIMER

Although the work described in this volume has been funded wholly or in part by the United States Environmental Protection Agency through Contract No. 68-01-6388 to JRB Associates, Inc., it has not been subjected to Agency policy review, does not necessarily reflect the policy views of the Agency, and no official endorsement should be inferred.

NOTE

The discussions reported in these proceedings are approximately verbatim, although the editors have assumed some license in the interests of continuity and brevity.

FOREWORD

The Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) and its subsequent amendments authorize the Environmental Protection Agency (EPA) to designate ocean dumping sites. Based on the authorization and requirements of the Act, the EPA issued the Ocean Dumping Regulations (ODR) on January 11, 1977. The ODR established 5 general criteria and 11 specific criteria to be considered in the selection of ocean disposal sites for the disposal of dredged material, to allow the Corps of Engineers (CE) to comply with the MPRSA. These sites were to be used for an interim period by the CE, pending completion of site designation studies required by the ODR. Use of these sites by the CE would be dependent on compliance with the criteria contained in the ODR and presented in an Environmental Impact Statement (EIS).

Those sites given interim designation were selected by EPA and the CE, with the size and location of each site based on historic use. The interim designations were to remain in force for a period not to exceed 3 years (until January 1980) from the date of the final promulgation of the ODR. However, due to the length of time required to complete the necessary environmental studies and due to technical and budgetary operating restraints, the environmental studies were not completed within the approved 3-year period. As a result, the Regulations were amended in January 1980 to extend the interim designations of those sites currently under study for a period not to exceed 3 years (until January 1983). The remaining sites' interim designations were extended indefinitely, pending completion of studies and determination of the need for continuing use. At the present time, efforts are being made for an additional extension of the interim designations for the sites under study.

The EPA is committed to preparing 29 environmental assessments for the permanent designation of ocean disposal sites. Twenty-two of these are required by a Consent Agreement between the EPA and the National Wildlife Federation. Six are being prepared pursuant to an agreement between the CE and the EPA, and one is being prepared at EPA's initiative.

EPA initiated the baseline trend assessment studies on the 29 sites in July 1977 by contracting with Interstate Electronics Corporation (IEC). These studies were designed to characterize the interim sites' chemical, physical, and biological features and to evaluate alternative ocean disposal sites. Soon after the completion of the survey studies, it became apparent that a significant amount of additional funding would be needed to complete the Impact Statements. At that time the EPA decided to reduce the level of effort and eventually close out the contract. To complete the Environmental Impact Statements, a Task Force was established in the Criteria and Standards Division. This Task Force has been in existence for 2 years.

In developing these EIS documents, it became apparent that although there were problems unique to each EIS, there also were generic problems centering around the methodology used in evaluating site data and the subsequent conclusions drawn regarding present and future effects of disposal operations. Although sufficient amounts of data were collected and organized within each document, no consistent methodology had been developed for using these data to determine possible hazards or effects associated with the disposal operation. It is felt that the existing data could be interpreted more effectively in determining the effects of a disposal operation.

To assist in the development of a generic assessment methodology, a Workshop for the Development of a Scientific Protocol for Ocean Dump Site Designation was organized and conducted at the W. Alton Jones Campus of the University of Rhode Island on February 14-17, 1983. The following report constitutes the proceedings of that workshop. The workshop attendees included approximately 30 scientific and technical experts in the fields of physical, chemical, and biological oceanography. In addition, a number of individuals from various EPA regulatory offices and from other institutions and organizations were invited to attend as resource persons and observers. JRB Associates of McLean, Virginia assisted EPA in planning and coordinating the workshop.

The proceedings were prepared by Dr. Mark Reed of Applied Science Associates, Inc., Wakefield, Rhode Island, and Dr. Victor J. Bierman, Jr., of the EPA Environmental Research Laboratory, Narragansett, Rhode Island. Dr. Paul Campanella and Ms. Sara Barr of JRB Associates, McLean, Virginia provided technical editing. The proceedings contain recommendations for the development of an operational technical guidance manual for ocean dump site designations, with emphasis on dredged material disposal in shallow coastal environments. As such, these recommendations have not been adopted as official EPA policy and no official EPA endorsement should be inferred.

The EPA requests that other agencies and individuals provide any comments or suggestions for improving the present preliminary dumpsite designation protocol and the recommendations contained therein. Such comments or suggestions should be submitted to Mr. Chris Zarba, Criteria and Standards Division (WH-585), Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C. 20460.

Patrick M. Tobin, Acting Director
Criteria and Standards Division

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1. WORKSHOP OVERVIEW AND SUMMARY

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Background

The U.S. EPA has been given a legislative mandate to designate sites for ocean disposal of waste materials. The materials of general concern are dredged materials, sewage sludge, and industrial wastes. The present designation procedure consists of preparing an Environmental Impact Statement (EIS) for each proposed site. This procedure can lead to inconsistency in the way designation decisions are made and in the acquisition of information that is not germane to particular decisions. This approach to site designation has met with criticism and has prompted an effort by EPA to develop a useful, scientifically credible protocol for the site designation process.

Approach

To assist in developing the protocol, a workshop was convened and attended by approximately 30 scientific and technical experts in the fields of physical, chemical, and biological oceanography. A deliberate effort was made to identify attendees with particular expertise and interest in the various aspects of ocean disposal problems. In addition, a number of individuals from various EPA regulatory offices and from other institutions and organizations were invited to attend the workshop as resource persons and observers.

The principal objective of the workshop was to develop a consensus, state-of-the-art protocol for the acquisition, organization, and interpretation of information for the purpose of designating ocean dump sites. The principal criteria for the protocol were utility and scientific credibility. To ensure that the workshop discussions were well-focused, a "strawman" site designation protocol was developed to serve as an initial working document. This document was distributed for review to all attendees approximately 1 month before the workshop.

Workshop Format

The workshop was organized into four different task groups, each corresponding to one of the principal components in the protocol. Time was divided between individual task group meetings and plenary meetings. These meetings were intensive working sessions. Attendees were asked to review, criticize, revise, and if necessary, re-formulate the "strawman" protocol. Each task group, under the leadership of a group chairperson, was asked to produce a report summarizing their recommendations and documenting all of their discussions. Task group reports were presented at the final workshop session.

The four workshop task groups and chairpersons, and key technical issues that were to be considered are listed below. These issues were preliminary and were not intended to be all inclusive. The specific charges to the task groups were modified in some cases as the workshop progressed.

Workshop Task Group Charges

I. Exposure Assessment Methodologies
Chairperson: Thomas P. O'Connor
NOAA/OMPA

Issues:
- Spatial and temporal scales
- State variables
- Deterministic models
- Statistical models
- Environmental forcing functions
- Sediment-water interactions
- Chemical partitioning
- Chemical transformation
- Exposure-residue linkages
- Minimum data set requirements

II. Hazard Assessment

A. Exposure Assessment Sub-Group
Chairperson: William A. Brungs
EPA-Narragansett

Issues:
- Water quality criteria
- Sediment criteria
- Chemical partitioning
- Bioavailability
- Exposure-residue linkages
- Probabilistic analyses
- Minimum data set requirements

B. Effects Assessment Sub-Group
Chairperson: John H. Gentile
EPA-Narragansett

Issues:
- Endpoints
- Toxicology
- Biotic residues
- Pathogens
- Bioavailability
- Short-term predictive responses
- Long-term integrative responses
- Site-specific criteria
- Minimum data set requirements

III. Policy Issues

Chairperson: Tudor T. Davies
EPA-Office of Water

Issues: Ultimate assimilative capacity
Historical versus alternative ocean dumping sites
Disposal of metals in dispersive sites
Disposal of organics in containment sites
Cost versus risk
External guidelines for protocol implementation

Workshop Summary

A hazard assessment approach for estimating the environmental impacts of ocean-dumped wastes was endorsed. This approach had been used as the underlying rationale for development of the "strawman" document. Specific methodologies were proposed for exposure and effects assessments according to a two-tiered approach in terms of level of effort and the corresponding confidence limits. Recommendations were made for validation studies using existing data and for monitoring new disposal activities to provide data for validation of pre-disposal assessment results.

Apart from the technical aspects of the workshop, there was some confusion over the objectives and scope of the site designation process, as distinguished from the permit process, especially for dredged materials. The specific issue was what level of assessment, and hence what level of protection, should be imposed at each of the site designation and permit phases. The eleven (11) ocean dump site criteria (40 CFR 228.6) are stated in terms that are sufficiently broad to support a range of interpretations.

To ensure that the technical objectives of the workshop would be met, the technical task groups were asked to develop a set of methodologies for estimating the impact of disposal of a specific waste(s) at a specific site. The rationale was that although dump sites are designated for generic classes of waste (e.g., dredged materials, sewage sludge, industrial wastes, fly ash), the designation process is not initiated unless there is a specific waste(s) proposed for dumping. Operationally, the site designation process then becomes the problem of matching a specific waste(s) to a specific site. This operational similarity of site designation to the permit application process gave rise to some confusion. The policy task group addressed the latter issue and recommended that site designation be seen in the broad context of the overall approval system. This system spans a continuum from the initial search for a candidate site(s) to the actual disposal operation and management of the site. In this context, site designation was seen as a precursor to the permit process. However, it was recommended that the processes should be coupled, and should not be treated as separate regulatory acts.

2. A PROPOSED OCEAN DISPOSAL SITE DESIGNATION PROTOCOL: "STRAWMAN" DOCUMENT OVERVIEW*

Mark Reed
Applied Science Associates, Inc.
529 Main Street
Wakefield, Rhode Island 02879

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Appendix D: Basic Equations Supplied in the Protocol for Water Column and Sediment Exposure Field Calculations

Appendix E: Suggested Sources for Data and Information
References

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*Editors' Note: The full text and figures of the proposed protocol are available from:

Mr. Chris Zarba
U.S. Environmental Protection Agency
Criteria and Standards Division (WH-585)
Office of Water Regulation & Standards
401 M Street, SW
Washington, D.C. 20460

Abstract

Environmental impact assessments for dump site designations in the United States have generally been characterized by detailed catalogues of environmental data, subjective estimates of possible types of effects, and the lack of a systematic methodology for interrelating relevant information. The result has been expensive, time-consuming assessment efforts that are difficult to interpret. This paper discusses a proposed hazard assessment protocol that seeks to improve the scientific credibility of marine dump site assessments, as well as focus data collection and evaluation, with a potential attendant reduction in total effort. These goals can be achieved through the adoption of an assessment methodology that incorporates the major processes governing the distribution of ocean-dumped wastes, providing an interpretive framework for evaluating ecological exposure and effects. Placing the assessment process in this framework allows the determination of data required to select and adequately evaluate a marine waste disposal site. This will permit efforts and resources to be focused on collection of information necessary for site designation decisions. Given a generic type of waste (e.g., dredged material, sewage sludge, or industrial by-products), the protocol guides a user to a decision on the appropriateness of a specific geographical site, or the desirable generic characteristics of a potential site.

1. Introduction

A large number of ocean waste disposal sites are designated annually by the U.S. Environmental Protection Agency (EPA), under authority of the Marine Protection, Research, and Sanctuaries Act of 1972. It is essential that these decisions be rational, consistent, expeditious, and as scientifically credible as possible given reasonable economic limitations. This paper provides an overview of a proposed ocean waste disposal dump site designation protocol. The protocol incorporates a series of mathematical exposure assessment and biological mapping procedures intended to characterize a particular marine location in terms of its capability to receive a particular type of waste and minimize environmental impacts. The approach is in accord with the hazard assessment strategy for ocean waste disposal developed by Bierman et al. (1982), and applied by Paul et al. (1983). A similar conceptual approach was employed by Reed et al. (1980) and Spaulding et al. (1982) in addressing the oil spill-fishery impact estimation problem. The strategy is to attempt realistic assessments using existing data, acquired data, and environmentally conservative assumptions in the face of uncertainty. The protocol is intended to supply a set of scientific methods for ocean waste disposal site designation such that

(1) necessary physical, chemical, and biological information is clearly specified
(2) application of the protocol results in an integrated synthesis of that information, from which biological and human health impacts can be estimated
(3) designation studies can be performed by scientists with some practical experience in the designation process.

It is important to stress that in the United States, marine waste disposal site designation is a generic, data limited exercise, as opposed to the waste-specific permit application process (Figure 1). A site is designated only for a general class of waste, such as sewage sludge or dredged material. Any applicant wishing to use the site for disposal of a specific waste is required to complete the permit application process, in which a more detailed assessment is conducted of the potential impacts of the particular waste on the designated disposal site.

Site designation is therefore viewed here as properly requiring a relatively low level of effort, and the following considerations are not included in the protocol. First, the assessment of cumulative large-scale multiple site impacts is assumed to be outside the scope of the designation process for any single site. It is inefficient to repeat a large assessment effort for every incremental designation. A more rational approach is to conduct the processes of site designation and permit issuance within the framework of large-scale regional assimilative capacity studies. Second, no monitoring or other field studies are necessarily required to designate a site according to the proposed protocol. Since many sites under consideration have been used previously, sufficient field data are often already available. For new sites, a field survey may be necessary, in which case the protocol specifies the information that should be collected, eliminating redundant or extraneous efforts.

The proposed protocol has been developed under the modeling philosophy shown in Figure 2. The real-world problem being modeled is termed the prototype. It is clearly neither desirable nor possible to represent the full complexity of the prototype in the model; some degree of reduction is sought. This simplification proceeds based on a careful consideration of the basic purposes of the model, dictating which prototype processes will be included. In the present case, the reduction process is guided by the fact that the rationale for a designation decision should be is based on an assessment of the potential hazard to the environment posed by the proposed waste disposal strategy, to the extent that such a strategy has been defined at the designation stage. The protocol therefore represents a realization of the hazard assessment methodology discussed by Bierman et al. (1982), providing an interpretive framework for estimating the probability of harm to the marine environment.

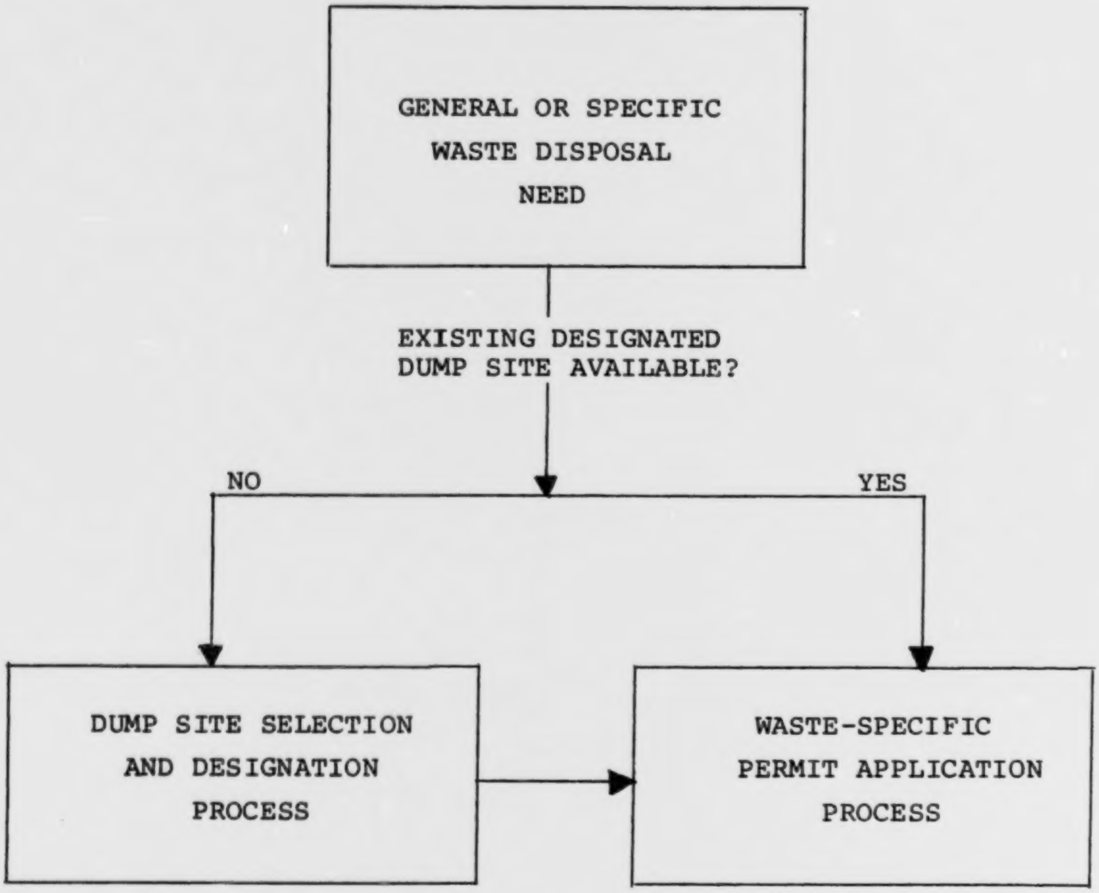
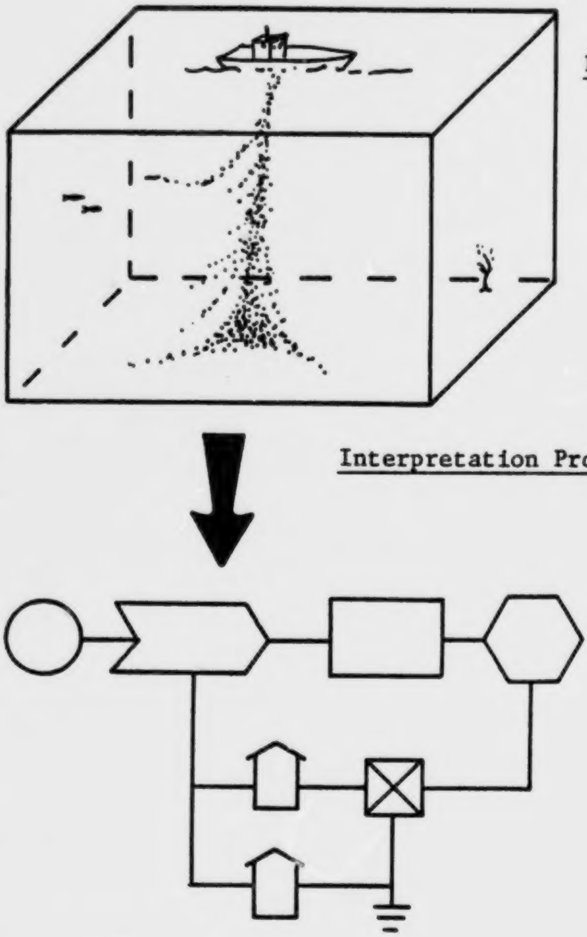

GENERAL OR SPECIFIC WASTE DISPOSAL NEED
EXISTING DESIGNATED DUMP SITE AVAILABLE?
NO
YES
DUMP SITE SELECTION AND DESIGNATION PROCESS
WASTE-SPECIFIC PERMIT APPLICATION PROCESS

Figure 1. Relationships of the dump site designation and permit application processes. The dump site selection and designation process involves general hazard assessments for anticipated classes of wastes. Permit process hazard assessments are both waste- and site-specific.



Prototype: Set of real environmental and disposal activity attributes

Interpretation Process: Selection of attributes for model (protocol) representation

Impact assessment model (protocol) = ordered aggregation of the selected subset of attributes

Figure 2. Relationship between prototype and model.

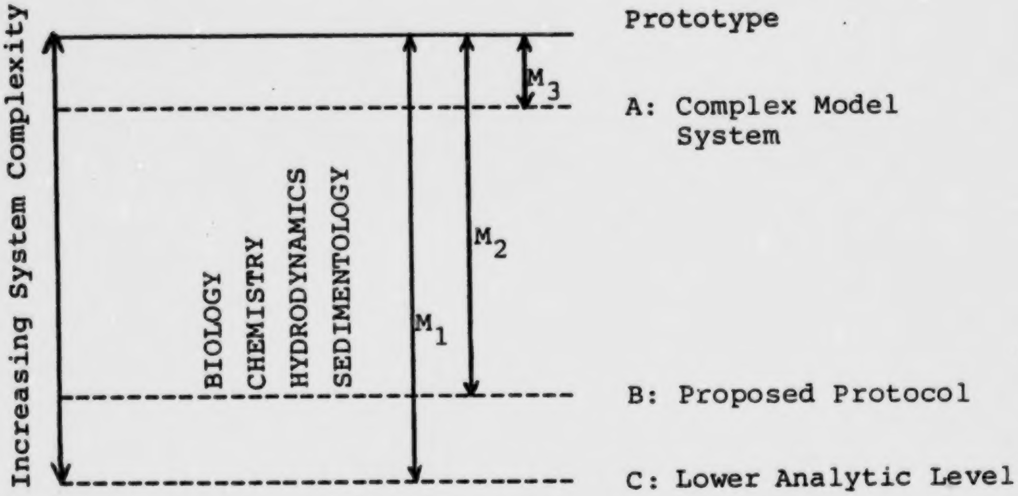

Increasing System Complexity
Prototype
A: Complex Model System
B: Proposed Protocol
C: Lower Analytic Level
BIOLOGY
CHEMISTRY
HYDRODYNAMICS
SEDIMENTOLOGY
M_1
M_2
M_3

Figure 3a. Continuum of representational complexity. The metric M measures the ability of the model to simulate the behavior of the prototype. The skills of a team of highly trained specialists would be required to achieve Level A.

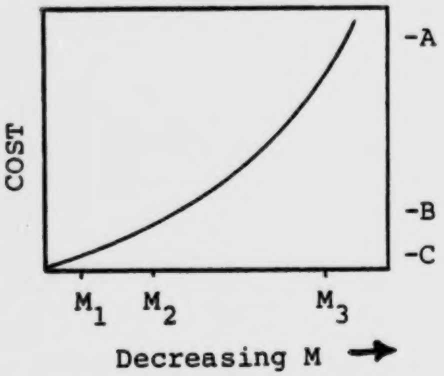


Figure 3b. Approximate relationship of time and effort (cost) to improved predictive ability (lower value of M).

The more accurately a model portrays those processes of interest in the prototype, the more useful the model is in estimating the real-world impacts of a particular dumping strategy. As shown in Figure 3a, we can consider some metric which is a measure of the model's ability to simulate the behavior of the prototype. As this metric becomes smaller, the model gets "closer" to the prototype in its response to dumping impacts. As the realism of the model and the strength of the supporting data base increase in each of the biological, chemical, hydrodynamic, and geological aspects, the metric decreases, and the predictive value of the model will generally improve. As Figure 3b suggests, the cost in time and effort of carrying out studies at higher levels of complexity is also non-linearly related to the costs associated with simpler approaches. Level A in Figure 3a represents the full state of the art, an effort of several person-years, and considerable sophistication. Improvements beyond this level are time-consuming and represent major research efforts.

Again, the designation process is a first-level evaluation that is followed by more detailed, waste-specific studies for each waste for which a dumping permit is sought. Although both the designation and permit processes should be based on an expeditious and scientifically sound hazard assessment rationale, the level of effort for site designation is not as high as for the permit application process. The dumping permit can therefore be seen as imposing a second level of protection on the designation decision.

Both cost and procedural considerations indicate a relatively low level of effort at the designation stage. The proposed dumpsite protocol has been formulated on that basis, given that the methodology must be scientifically credible, consistent, and reliable. The methodologies described are based on numerical calculations that can be carried out on a hand-held scientific calculator, although a microcomputer-based system will be more efficient and reliable. In some situations, such as highly sensitive biological areas combined with complex hydrodynamics, or closely situated multiple sites, this simple engineering approach may be insufficient. A coupled hydrodynamic - biological computer modeling approach with a coordinated field survey effort is the preferred methodology in such cases.

2. Marine Dump Site Designation Protocol Overview

Figure 4 shows the serial structure of the proposed protocol, which guides a designation team through the hazard assessment of a specific candidate receiving site. In Stage 1, a basic set of site-specific information is assembled and a preliminary evaluation is made. In Stage 2, a representative set of waste characteristics is established for impact assessment purposes. Stage 3 prescribes the mapping of water column and sediment impact areas, based on transport, dispersion, sediment

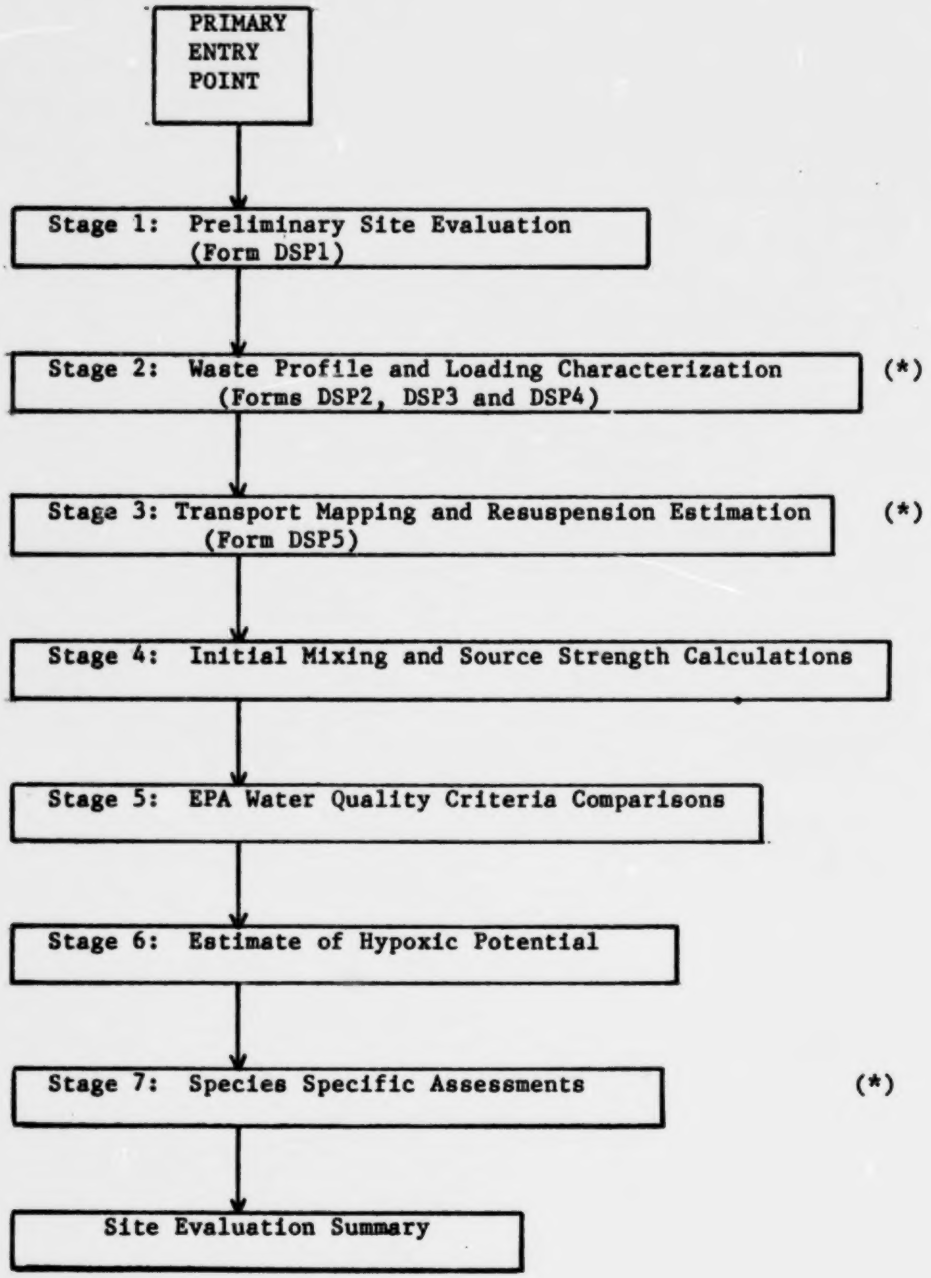

PRIMARY
ENTRY
POINT
Stage 1: Preliminary Site Evaluation (Form DSP1)
Stage 2: Waste Profile and Loading Characterization (Forms DSP2, DSP3 and DSP4)
(*)
Stage 3: Transport Mapping and Resuspension Estimation (Form DSP5)
(*)
Stage 4: Initial Mixing and Source Strength Calculations
Stage 5: EPA Water Quality Criteria Comparisons
Stage 6: Estimate of Hypoxic Potential
Stage 7: Species Specific Assessments
(*)
Site Evaluation Summary

Figure 4. Ocean dump site designation protocol structure. Although the format is basically serial, secondary independent entry points are identified by asterisks(*) to facilitate the organization of 2 or 3 person team-designation efforts.

deposition, and resuspension calculations. These computations are based on unit concentration source strengths. The results are recorded on a family of reporting forms (Appendix B) and user-supplied basemaps of the area in question. Stage 4 supplies methodologies for estimating initial waste dilution factors, so that estimates of anticipated waste component exposure levels can be inferred from the Stage 3 transport contours, and can be compared with EPA Marine Water Quality Criteria in Stage 5. A possible result of dumping waste that contains organic components is a local reduction in dissolved oxygen. Stage 6 outlines methodologies for estimating the likelihood of a hypoxic or anoxic event due to the proposed dumping activity. Stage 7 allows for simple species-specific impact assessments, based on spatial and temporal distribution of local populations and available data for acute and/or chronic toxicity.

Protocol Stage 1: Preliminary Site Evaluation

This evaluation stage is based on the assumption that only a few ocean dump site criteria result in automatic site rejection. These are

(1) Marine sanctuary
(2) Interference with navigation
(3) Military exclusion area
(4) Legitimate engineering uses of the seafloor (such as underwater cables).

Other considerations, such as fish spawning and nursery areas, will in general require some level of assessment (i.e., further application of the protocol) to determine the extent of any potential impacts.

As part of Stage 1, a standard protocol form (Appendix B) is completed describing the site in general geographic terms. One or more basemaps of the area must be produced, to show bathymetric and coastal features. The basemaps serve as figures for the summary report, and for mapping of transport phenomena.

Protocol Stage 2: Waste Profile and Loading Characterization

The purpose of this stage is to define representative waste characteristics and contaminant loading rates. Existing and potential waste sources supply the impetus for a designation effort. The physical and chemical composition of the wastes must be known to assess environmental behavior and fate. The focus here is on the collection of the physical and chemical information needed to characterize a typical waste expected to be dumped at the site. Existing data or waste analyses will be required at this step.

In the case of a specific waste from a single source, there is no question about what waste to use in the designation study. If there are specific wastes from multiple sources, as is the case for most historically used sites being redesignated, the protocol recommends basing the designation study on a composite waste, calculated by weighting each source by its estimated volumetric annual loading. Other options are to use the most toxic of the wastes ("worst case" approach), or the most probable waste.

Protocol Stage 3: Transport Mapping and Resuspension Estimation

Mean or characteristic transport contour maps are constructed for typical and episodic (storm) conditions, and sediment resuspension probabilities are evaluated. The physical environment is considered in three subdivisions, or physical domains:

- Upper water column (above pycnocline)
- Lower water column (below pycnocline)
- Sediments

These domains (Figure 5) correspond to the pelagic, demersal, and benthic biological categories of Stages 5, 6, and 7.

In general, transport contours are calculated for each domain for long term (chronic) and short term (acute) time frames. If there is no season of the year during which a pycnocline is typically present, or if upper and lower water column net drift estimates are the same, then only one set of water column transport contours needs to be calculated for the long term time frame. If seasonal conditions significantly alter the pycnocline location, additional sets of contours will be needed to adequately describe concentration limits.

The transport formulations used are all one or two dimensional in space. The "near-field" conceptualization of the source is shown in Figure 5. The near-field water column dispersion and transport is described by an equation whose graphical form is sketched in Figure 6. The procedure is designed to supply an estimate of the distribution and dilution of waste following initial mixing calculations.

The far-field waste cloud dispersion formulations are shown graphically in Figure 7. Because vertical dimensions of waste plumes are generally very small (on the order of 10 to 100 meters) compared to horizontal dimensions (on the order of 10 kilometers), and because the protocol is designated primarily for coastal applications, the two dimensional approximations are acceptable.

Figure 8 shows the processes represented in the protocol for estimating the mass balance of wastes on the sea floor. The input rate is the average dumping rate. Resuspension is estimated from the sum of the tidal velocities, net bottom currents, and the wave induced bottom velocities. The accumulation of any particular waste constituent on the sea floor

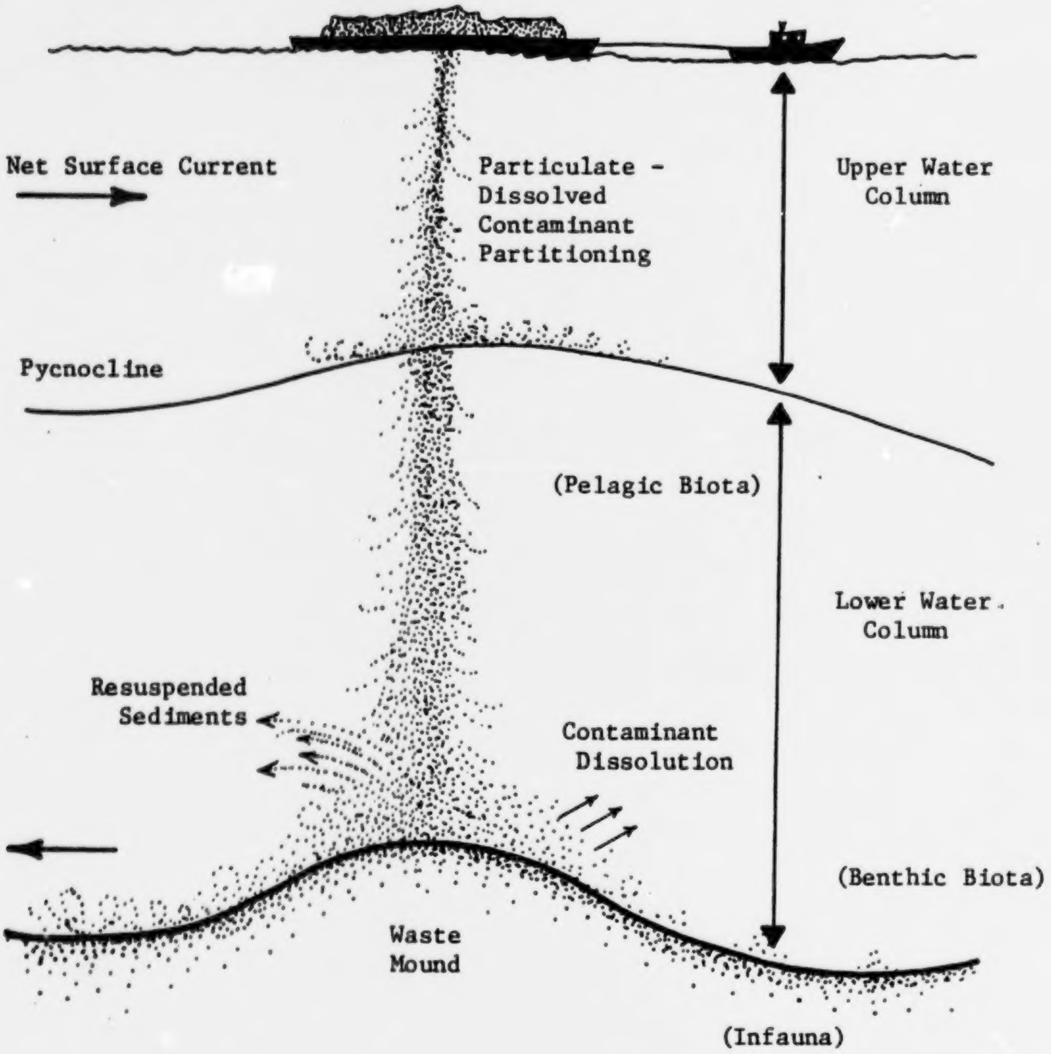

Net Surface Current
Particulate - Dissolved Contaminant Partitioning
Upper Water Column
Pycnocline
(Pelagic Biota)
Lower Water Column
Resuspended Sediments
Contaminant Dissolution
(Benthic Biota)
Waste Mound
(Infauna)

Figure 5. Mass balance conceptualization used in the protocol. The upper and lower water column and sediment compartments are associated with the pelagic, benthic, and infaunal biota for impact estimation purposes.

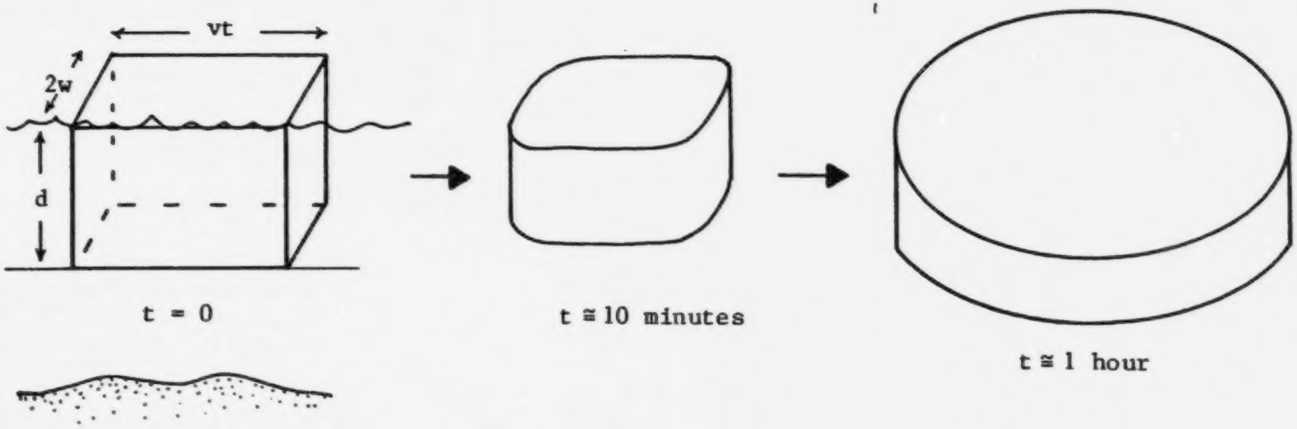

vt
2w
d
t = 0
t ≅ 10 minutes
t ≅ 1 hour

Figure 6. Graphic representation of analytic solution for near-field (upper or lower water column) exposure assessment immediately following a dump.

d = pycnocline depth (or pycnocline to sea floor depth)
w = barge width
v = towing speed
t = duration of dump

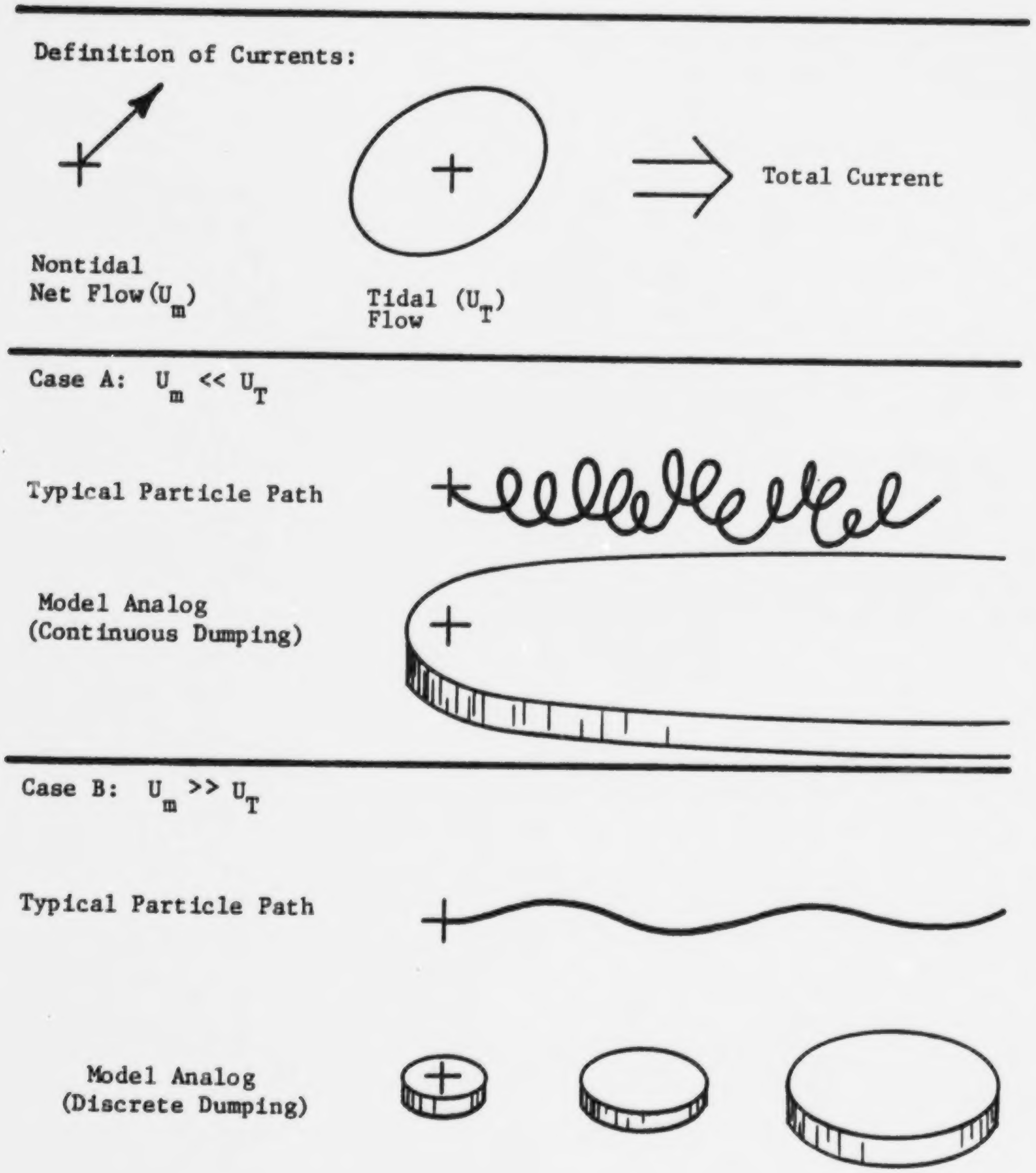

Definition of Currents:
Nontidal
Net Flow (U_m)
Tidal Flow (U_T)
Total Current
Case A: $U_m << U_T$
Typical Particle Path
Model Analog
(Continuous Dumping)
Case B: $U_m >> U_T$
Typical Particle Path
Model Analog
(Discrete Dumping)

Figure 7. Graphic representations of far field dispersion of waste cloud as modeled in the proposed protocol. (U_m = net nontidal flow; U_T = tidal flow)

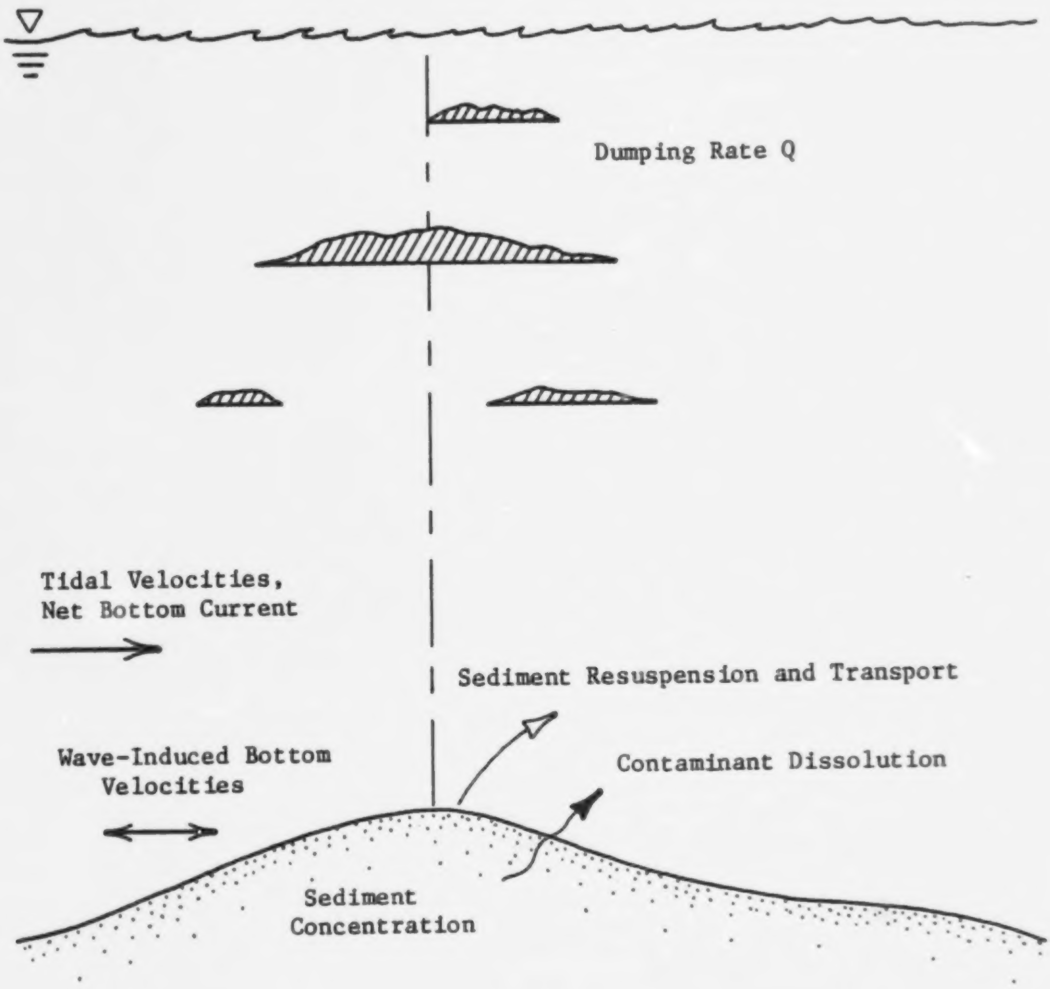

Dumping Rate Q
Tidal Velocities,
Net Bottom Current
Sediment Resuspension and Transport
Wave-Induced Bottom
Velocities
Contaminant Dissolution
Sediment
Concentration

Figure 8. Benthic waste accumulation is calculated considering the processes shown. A contaminant concentration profile in the sediments can be estimated as a function of time.

is then calculated as a balance among deposition, resuspension, and dissolution processes.

Protocol Stage 4. Initial Mixing and Source Strength Calculations

The purpose is to estimate the initial mass partitioning of the dumped material into the water column and sediment compartments. This estimate leads to values for mass input rates and initial concentrations required by the water transport equations in Stage 3, and values for mass input rates to the sediments. The procedures are designed to supply estimates of vertical and horizontal distributions of waste material at the time of dumping, prior to any transport. These distributions can also be used directly to estimate short-term contaminant concentrations in the immediate vicinity of the barge for comparison with the EPA Marine Water Quality Criteria in Stage 5. Given existing background contaminant concentrations, and bound/dissolved partition coefficients, the spatial concentration distributions of any desired component of the waste can be estimated, relative to the unit concentration scaling maps produced in Stage 3, or the EPA Criteria in Stage 5.

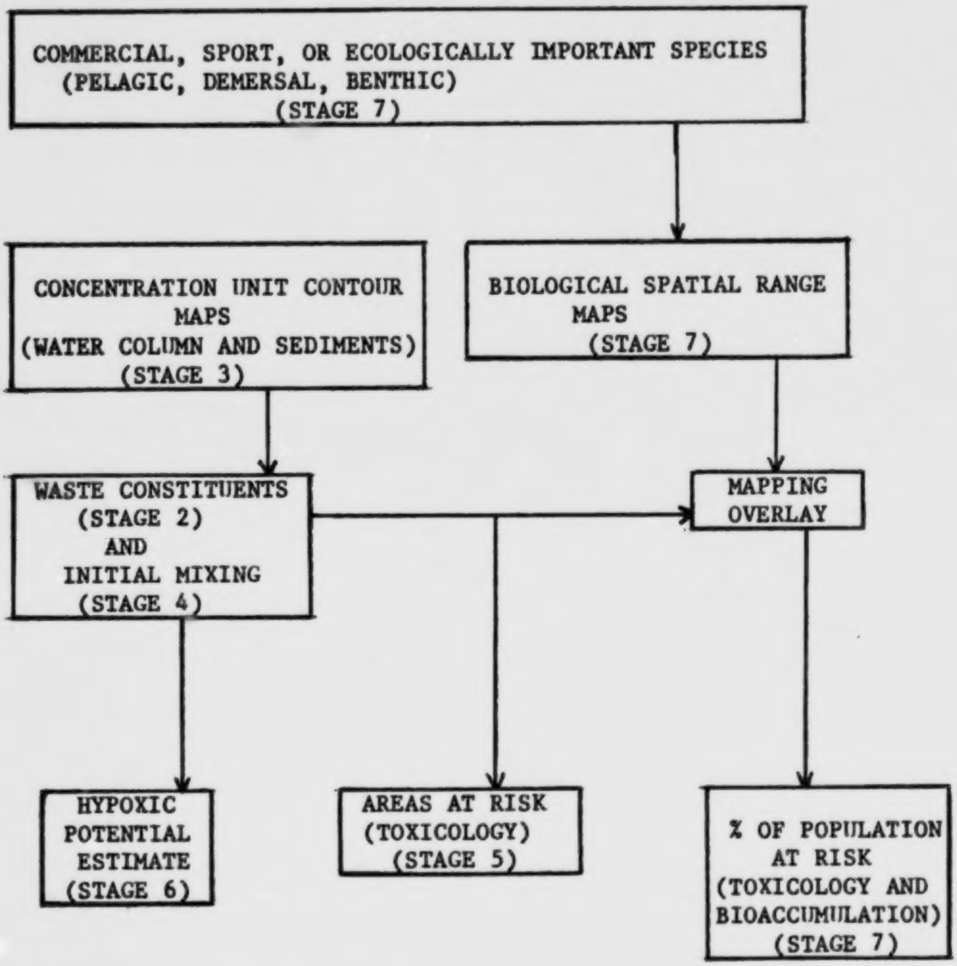
Protocol Stage 5: EPA Water Quality Criteria Comparisons

This stage supplies a simple methodology for biological impact assessment in the water column, based on a comparision of estimated water column concentrations at the dump site and EPA Marine Water Quality Criteria as shown in Figure 9. Acute and chronic marine water quality criteria are supplied in the protocol, along with estimates of particulate-dissolved phase partition coefficients for selected contaminants. The procedures permit estimates of near-field (acute) and far-field (chronic) concentrations for waste constituents of interest. Partition coefficients describe the tendency of many contaminants, such as metals and some organic compounds, to adhere to fine suspended particles rather than to dissolve into the water itself. The protocol supplies a standard form for summarizing the results of the comparisons.

As discussed in Paul et al. (1983), the EPA marine water quality criteria are based on the most comprehensive data base available for evaluating acute, chronic, and bioaccumulation responses (EPA 1980). These criteria also provide a relatively simple means of using species-specific data to provide for a general level of ecosystem protection.

Paul et al. (1983) emphasizes three limitations to the use of the criteria as a toxicological data base to estimate acceptable contaminant concentration levels for the protection of marine life. First, the data base supporting the criteria is developed in the laboratory using primarily estuarine species.

Figure 9. Impacts Evaluation Organization


COMMERCIAL, SPORT, OR ECOLOGICALLY IMPORTANT SPECIES (PELAGIC, DEMERSAL, BENTHIC) (STAGE 7)
CONCENTRATION UNIT CONTOUR MAPS (WATER COLUMN AND SEDIMENTS) (STAGE 3)
BIOLOGICAL SPATIAL RANGE MAPS (STAGE 7)
WASTE CONSTITUENTS (STAGE 2) AND INITIAL MIXING (STAGE 4)
MAPPING OVERLAY
HYPOXIC POTENTIAL ESTIMATE (STAGE 6)
AREAS AT RISK (TOXICOLOGY) (STAGE 5)
% OF POPULATION AT RISK (TOXICOLOGY AND BIOACCUMULATION) (STAGE 7)

Applicability to oceanic forms has in general not been established. Second, criteria developed for single contaminants are not necessarily additive when considering multiple contaminant effects. Third, the criteria do not account for contaminant form (i.e. speciation) or phase (i.e. adsorbed versus dissolved).

With regard to contaminant form, the use of total concentration in exposure analysis is consistent with the total concentration as used in the development of the water quality criteria. In the development of the criteria, it was assumed that the total concentration of the compound was biologically available. These criteria, however, were developed in particulate-free laboratory dosing systems, so the comparisons made here only approximate the contaminant-particulate system that actually exists in the aquatic environment. Through specification of contaminant partition coefficients, the protocol contains the option of estimating dissolved phase concentrations and using these values for comparison with the water quality criteria, rather than total contaminant concentrations.

The water quality criteria are expressed as two numbers: a maximum concentration and a 30-day average concentration. The two-numbered criterion is intended to define the highest average concentration of a contaminant consistent with the maintenance of aquatic life, while restricting the extent and duration of excursions over the average, so that the total exposure will not cause unacceptable adverse effects.

The maximum component of the criterion is designed to limit acute lethality and is based upon a compilation and analysis of acute toxicity data from a minimum of eight taxonomic families. This value is intended to protect 95 percent of the species with similar sensitivity to those tested, when the cumulative deviation of excursions above the specified 30-day average concentration is limited to 96 hours in any 30 consecutive days.

Derivation of the 30-day average component of the criterion involves interpretation of data bases on chronic toxicity to animals and plants, bioaccumulation, and other biologically significant effects of ecologically or economically important resource populations (Paul et al., 1983).

Protocol Stage 6: Hypoxic Event Potential Assessment

Recent dissolved oxygen information will usually reveal whether or not hypoxia is a common problem in the region around the site. The amount of dissolved oxygen in seawater is primarily a function of photosynthesis and respiration by aquatic biota, temperature, reaeration from the atmosphere, and vertical mixing. High water temperatures result in low oxygen saturation values, and quiescent weather results in low energy input into the ocean, low vertical mixing, and therefore the formation of strong pycnoclines. Thus summer usually represents the critical season for analysis. The protocol methodologies, outlined in Figure 10, provide an estimate of the time during which these critical conditions must be present to result in hypoxia at the site.

Protocol Stage 7: Species-Specific Assessments

The previous protocol stages provided estimates of spatial exposure concentrations due to the proposed waste disposal activity, followed by comparisons with EPA Water Quality Criteria. The focus of Stage 7 is on more detailed analyses of impacts on specific species, specific biological types, or ecological communities of concern. Impacts on species in the upper and lower water column and benthic communities can be investigated. Figure 11 shows a suggested tabular organization for reporting results of these evaluations. These biological groups correspond to the three exposure environments already evaluated in Stages 3 and 4. The relationship of Stage 7 to previous protocol stages is shown in Figure 9.

Commercially harvested species are an important group for impact estimation, both because of the likelihood that adequate data on their distributions will be available and because of the close linkage to human health effects. The relative spatial scales of species' distributions and the contaminants introduced by the dumping are of primary interest. Consideration of spawning migrations and distributions of early life history stages with limited motility and/or high sensitivity to contaminants are important. Species-specific assessments are based on an estimate of the fraction of the particular local population that will be affected by the proposed dumping.

Bioaccumulation and sublethal effects are concerns in commercially harvested species as well as in species upon which they feed. Figure 12 shows the series of calculations suggested in the protocol for estimation of bioaccumulation by a benthic organism. The selection of contaminants for hazard evaluation should be based on a comparison of concentrations in the waste (for benthic organisms) or after initial dilution (for pelagic organisms) with FDA action limits or the EPA Water Quality Criteria given in the protocol. The EPA Water Quality Documents (1980) are an excellent source of information for species-specific efects. A table supplied in the protocol lists selected bioconcentration factors for a number of synthetic organic compounds.

Specify Critical Conditions for Analysis:

- Maximum Dumping Rate
- Low Diffusivities
- Maximum Temperature
- Low Flow

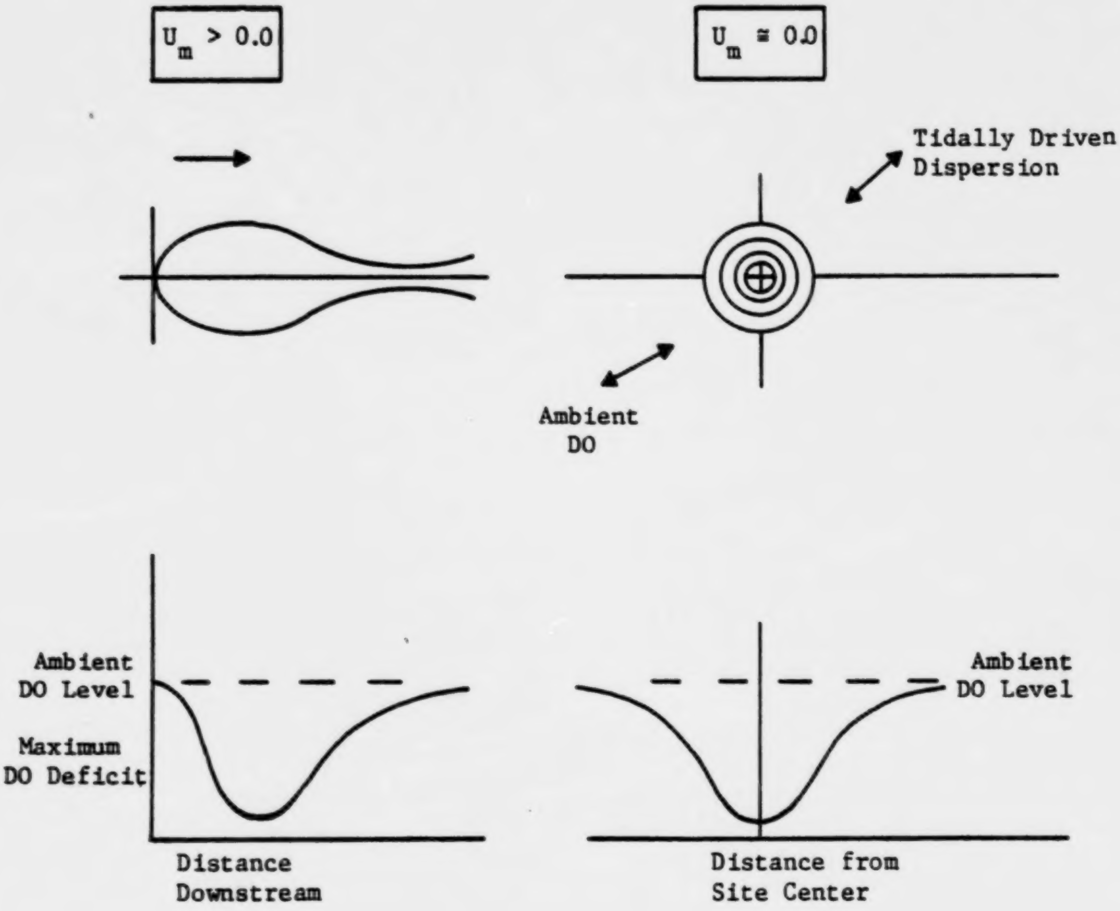

$U_m > 0.0$
$U_m \cong 0.0$
Tidally Driven Dispersion
Ambient DO
Ambient DO Level
Maximum DO Deficit
Distance Downstream
Ambient DO Level
Distance from Site Center

Figure 10. Hypoxic event potential analyses.
(U_m = nontidal net flow; DO = dissolved oxygen)

DOMAIN	GENERIC TYPE	SITE SPECIFIC SPECIES	POLLUTANT	ACUTE CRITERION	CHRONIC CRITERION	FDA TISSUE LIMIT
PELAGIC	Phyto-Plankton					
	Zoo-Plankton					
	Finfish (Herring)					
DEMERSAL	Crustacean or Mollusk					
	Finfish (e.g. Cod)					
INFAUNAL	Mollusk					
	Polychaete					

Figure 11. Example format for effects assessment. Rather than "Generic Type", one could consider species, population, community, or functional group.

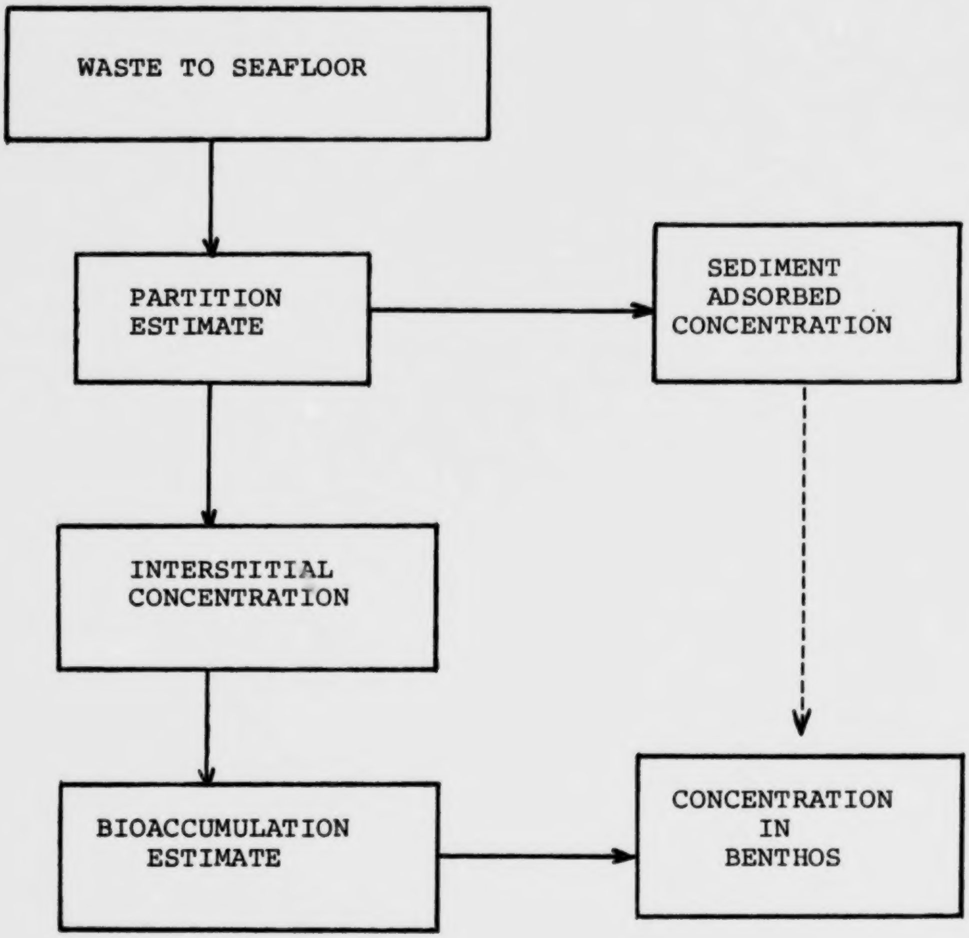

WASTE TO SEAFLOOR
PARTITION ESTIMATE
SEDIMENT ADSORBED CONCENTRATION
INTERSTITIAL CONCENTRATION
BIOACCUMULATION ESTIMATE
CONCENTRATION IN BENTHOS

Figure 12. Calculation pathway for bioaccumulation estimation for a benthic species. Food chain uptake is not included in the Protocol estimation procedures.

3. Conclusion

A suggested ocean waste disposal site designation protocol has been presented in overview. Previous designation efforts (e.g., COE 1981; EPA 1982a; EPA 1982b; EPA 1982c) have been characterized by the collection and collation of data and information without the benefit of a structured methodology for evaluating implications. The protocol proposed here is an ordered methodology designed to produce exposure and hazard assessment estimates, such that environmental effects can be rationally evaluated and compared among alternative sites. It is hoped that we will be able to evaluate, criticize, and improve on this document during this workshop.

Acknowledgements

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APPENDIX A: 11 OCEAN DISPOSAL SITE SELECTION CRITERIA
(From Federal Register CFR Title 40, Section 228.6)

(1) Geographical position, depth of water, bottom topography, and distance from coast.

(2) Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile phases.

(3) Location in relation to beaches or other amenity areas.

(4) Types and quantities of wastes proposed to be disposed of and proposed methods of release, including methods of packing the waste, if any.

(5) Feasibility of surveillance and monitoring.

(6) Dispersal, horizontal transport, and vertical mixing characteristics of the area, including prevailing current velocity, if any.

(7) Existence and effects of present or previous discharges and dumping in the area (including cumulative effects).

(8) Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific importance, and other legitimate uses of the ocean.

(9) Existing water quality and ecology of the site as determined by available data or by trend assessment of baseline surveys.

(10) Potentiality for the development or recruitment of nuisance species in the disposal site.

(11) Existence at or in close proximity to the site of any significant natural or cultural features of historical importance.

APPENDIX B. INFORMATION FORMS INCLUDED IN THE PROPOSED MARINE DISPOSAL SITE DESIGNATION PROTOCOL

FORM DSP1: BASIC SITE CHARACTERIZATION INFORMATION

VARIABLE NAME	VALUE	UNITS	SOURCE/COMMENTS
SITE CENTER LATITUDE			ASSIGNED
LONGITUDE			ASSIGNED
WIDTH		km	ASSIGNED
LENGTH		km	ASSIGNED
ORIENTATION OF LONGEST DIMENSION			ASSIGNED
SITE SHAPE			ASSIGNED
DISTANCE TO NEAREST (1) COASTLINE		km	
(2) FISHERY AREA		km	
(3) RECREATIONAL AREA		km	
(4) SHIPPING LANE		km	
(5) MILITARY EXCLUSION ZONE		km	
(6) OCEAN DUMPSITE		km	
(7) MARINE SANCTUARY		km	
(8) ENGINEERING USES OF SEAFLOOR (SPECIFY)			
(9) LIVING RESOURCES			

FORM DSP2: WASTE SOURCE AND LOADING CHARACTERIZATION

VARIABLE NAME	VALUE	UNITS	COMMENTS (Text Symbol)
WASTE TYPE			
ANNUAL LOADING RATE		m^3/yr	(Qa)
TYPICAL DURATION OF DREDGING OPERATION		fraction of year	(Tdd)
TYPICAL NUMBER OF DUMPS/DAY			(Dd)
BULK SPECIFIC WEIGHT		none	(sw_{bulk})
LIQUID PHASE SPEC. WT.		none	default: 1.0 (sw_{liquid})
PARTICLE SPEC. WT.		none	default: 2.65 (sw_{part})
CLAY-SILT/SAND-GRAVEL (FINE/COARSE) FRACTIONS (TOTAL SOLID PHASE)		none	(Ff/Fc)
VOLUMETRIC SOLID/LIQUID FRACTIONS		none	(Fs/Fl)
FRACTION OF FINES IN SUSPENDED CLOUD (SINGLE DUMP)		none	default: 0.9 (Ffs)
DISPOSAL VESSEL VOLUME		m^3	(V_b)
WIDTH		m	(w)
LENGTH		m	(l)
SPEED		m/sec	(v)
INDIVIDUAL DUMP DURATION FREQUENCY		sec per day	(t)

FORM DSP3: REPRESENTATIVE WASTE PROFILE DESCRIPTION
(MEAN CONCENTRATION OF CONSTITUENTS MEASURED IN SOURCE MATERIALS)
(mg/kg, EXCEPT SOLIDS)

	SOURCE A	SOURCE B	SOURCE C	SOURCE D	SOURCE E	WEIGHTED SUM (Cws)
FRACTIONAL CONTRIBUTION (Fi)						1.00
CONSTITUENT						
Percent Solids						
BOD						
DO						
pH						
Total Chlorinated HC						
Total Volatile Organics						
Cadmium						
Copper						
Lead						
Mercury						

FORM DSP4: GEOCHEMICAL SITE CHARACTERIZATION

CONSTITUENT OR CHARACTERISTIC	WATER COLUMN	SITE SEDIMENTS
	(PARTS PER MILLION OR MG/KG, EXCEPT SOLIDS)	
Percent Solids (Cs)		
Biochemical Oxygen Demand (BOD)		
Dissolved Oxygen(DO)		
pH		
Total Chlorinated HC		
Total Volatile Organics		
Cadmium		
Copper		
Lead		
Mercury		
SEDIMENTS ONLY:	SUMMER	WINTER
Percent Gravel		
Percent Sand		
Percent Silt		
Percent Clay		

FORM DSP5: PHYSICAL OCEANOGRAPHIC CHARACTERIZATION

VARIABLE NAME	VALUE	UNITS	SOURCE/COMMENTS (Text Symbol)
MAXIMUM DEPTH		m	
MINIMUM DEPTH		m	
MEAN DEPTH		m	(h)
PYCNOCLINE DEPTH		m	(hp)
TIDAL PERIOD		hr	(To)
ELLIPSE ORIENTATION		—	
MAJOR AXIS VELOCITY		m/sec	(Utx)
MINOR AXIS VELOCITY		m/sec	(Uty)
MEAN NET SURFACE DRIFT MAGNITUDE DIRECTION		m/sec	(Um)
MEAN NET BOTTOM DRIFT MAGNITUDE DIRECTION		m/sec	
MEAN WAVE AMPLITUDE PERIOD		m sec	(H) (T)
STORM INDUCED BOTTOM CURRENT		m/sec	
WATER TEMPERATURE (ANNUAL RANGE)		degrees Celsius	
pH (ANNUAL RANGE)			

FORM DSP6: WATER QUALITY CRITERIA COMPARISONS SUMMARY

SUBSTANCE	MAXIMUM		MAXIMUM 24 HOUR	
	ESTIMATED CONCENTRATION	EPA CRITERION	AREA EXCEEDING CRITERION	EPA CRITERION

APPENDIX C: LIST OF SUPPORT FIGURES AND TABLES SUPPLIED IN PROTOCOL

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APPENDIX D: BASIC EQUATIONS SUPPLIED IN THE PROTOCOL FOR WATER COLUMN AND SEDIMENT EXPOSURE FIELD CALCULATIONS

Two-Dimensional Point Source Plume Model

Calculate the long term average horizontal concentration field resulting from a continuous dumping operation in a field of uniform flow. This two dimensional plume analysis assumes that in the far field and in a long term average sense, the effects of individual dumping events will not be separable. This assumption is reasonable if the net velocity is less than the mean tidal velocity. It is also assumed that mixing across the net transport axis governs dilution. The governing equation (Fischer et al. 1979) is

$$C(x,y) = [q / (d \sqrt{4Pi*Dy*u*x})] \exp [-y^2 *u/4*Dy*x]$$

Where

C (x,y) = concentration at horizontal position x,y
q = mass input rate/sec = 1 for unit contours
Pi = 3.14159
exp = the exponential function
d = calculation depth (m), usually either the depth to the the pycnocline, depth of the bottom below the pycnocline, or total depth, depending on application.
Dy = cross-axis diffusion coefficient (m^2/sec)
u = net transport velocity (in x direction, m/sec)

The center of the site is taken as the origin (x = 0, y = 0). Holding y = 0, this equation can be solved for values of x corresponding to order of magnitude concentration reductions along the x axis. Off-axis values of y can then be calculated for a few intermediate values of x, and the concentration contours can be sketched.

If upper and lower water column net drift estimates are of different magnitudes or in different directions, then two unit concentration maps should be prepared. Realistic information will reflect a range of net drift magnitudes and directions. The unit concentration contour map should be based on average values, but directional ranges should be noted.

Two-Dimensional Discrete Cloud Model A: POINT SOURCE

As for the two dimensional plume described above, the x axis is oriented in the direction of net transport, with the y axis perpendicular. The solution of the two dimensional advection-diffusion equation is

$$C(x,y,t) = [Q/(4Pi*d*D*t)] \exp \left[-\frac{(x-Um*t)^2}{4*Dx*t} - \frac{(y)^2}{4*Dy*t} \right]$$

in which C(x,y,t), d, and Pi are as defined above. Q is the total mass of a given constituent in the water column. (Q = 1 for the generic unit concentration contours). D is calculated as the square root of the product Dx * Dy.

Two Dimensional Discrete Cloud Model B: INITIALLY DISTRIBUTED SOURCE

Let the original dump receiving volume have width a, length b, and depth d. The x axis conforms to the direction of mean flow, Um. Then the concentration C(x,y,t) is

$$C(x,y,t)=(Co/4)*[erf((b/2-x')/Ex) + erf((b/2+x')/Ex)]$$

$$*[erf((a/2 - y)/Ey) + erf((a/2 + y)/Ey)]$$

Where

erf = the error function (Table C-2);
Co = initial contaminant concentration
b = initial dump cloud dimension along x axis
a = initial dump cloud dimension along y axis
$Ex = (4*Dx*t)^{1/2}$
$Ey = (4*Dy*t)^{1/2}$
$x' = x - Um*t$
Um = mean flow velocity (Form DSP5).

These equations are time-dependent and permit the mapping of transport, growth and dissipation of single waste dump clouds. The result of this mapping process will be a series of "envelopes" for order-of-magnitude reductions in concentration. In other words, if Q or Co are set equal to 1.0, envelopes showing areas swept out by the 0.1, 0.01, and 0.001 concentration contours will be drawn on a single map.

Sediment Concentrations

That portion of the waste not suspended in the water column is added directly to the sediment compartment. It is assumed here that dumping is evenly distributed over the center of the site area, and that the benthic waste profile reflects this distribution in the absence of sediment resuspension and transport.

An approximation is needed to estimate the source strength represented by the sediments for various waste constituents of interest. O'Connor et al. (1983) have addressed this problem for sewage sludge deposited on the sea floor. Their formulation for the concentration of a contaminant in the sediment tends to give high estimates because it assumes no horizontal dispersion after the waste has settled to the bottom. The equation is one-dimensional in space, conforming to our uniformity assumption (no net transport direction) for the depositional pattern. The basic equation describing the vertical distribution of a constituent continuously supplied to and diffusing into a plane (Carslaw and Jaeger 1959) is:

$$C(z,t) = Q\,[(t/Pi*D)^{1/2} * \exp(-z^2/4*D*t) - (z/2*D) * \mathrm{erfc}\,(z/(4*D*t)^{1/2}]$$

where

C = concentration of contaminant in sediment (kg/m^3)

Q = contaminant depositional rate ($kg/m^2/yr$)

t = time (yr)

D = bioturbation mixing coefficient (default = $10^{-5}\ m^2/yr$)

z = depth into sediment (m), positive down

erfc(x) = 1 - erf(x) (Protocol Table C-2).

This equation assumes a constant value of the bioturbation "diffusion" coefficient. The value of D recommended above is low for deep sea sediments, and probably even lower relative to rates for coastal areas. O'Connor et al. (1983) point out that the choice of a low value will tend to minimize the penetration of contaminants into underlying sediments in the model, thereby increasing their availability for dissolution into the water column.

Near-Field Acute Exposure Estimates

For a specific waste constituent i, the maximum near-field acute water column exposure level (ELi) resulting from the dissolved, biologically available phase can be estimated from

$$ELi(ppb) = [Mi/(fi*Css)] + BLi$$

Where

Mi = concentration of constituent i after a dump (ug/kg)
$= Vb * Fs * Ci * 1000 / Vm$

Vb = volume of barge in cubic meters (Form DSP2)

Fs = solid fraction of waste (Form DSP2)

Ci = concentration of constituent i in the bulk waste (Form DSP3, mg/kg or ppm)

Vm = initial mixing volume (cubic meters)

fi = dimensionless partition coefficient for constituent i (Table C-1)

Css = suspended solids concentration subsequent to a dump (dimensionless mass ratio)
$= Ds * sw(part) + Cs$

Ds = dilution of suspended particulate phase (dimensionless)

Cs = background suspended solids concentration of the site (dimensionless mass ratio; Form DSP4).

BLi = background level of constituent i in the water column at the site (ppb; Form DSP4)

Compute Oxygen Depletion Curve for net flow Um>0.0.

The following formulation gives dissolved oxygen (DO) as a function of travel time from the site. Differences in nitrogenous and carbonaceous decay rates are neglected.

$$DO(t) = DOa - [DOa - DOi + BODult *(1 - \exp(-k *t))]*DS$$

The travel time t is related to distance x down-current by

$$x = Um*t$$

so that a graph of DO versus x can be constructed. DS, the downstream dilution subsequent to initial mixing, can be approximated from (Brooks 1960):

$$DS = [\mathrm{erf}\,(b^2/16D*t)]^{1/2}$$

Where

b = characteristic source length (= 200m, or the distance traveled by a barge during the dumping process);

D = constant lateral diffusion coefficient

$= 0.0018*b\ m^2/sec$

erf = the error function, (Protocol Table C-2).

If the graph of DO versus x or time t shows a minimum value below 2.0 mg/l, then there is reason to be concerned about hypoxic events under the specified conditions.

Compute Oxygen Deficit Growth Rate (for Um = 0.0)

The following methodology is based on the supposition that there may be little or no net flow during a worst case scenario, in which case the ambient dissolved oxygen available for dilution of an oxygen-poor cloud will also decrease with time. Although Li and Kozlowski (1974) have addressed the DO-sag problem for one dimensional oscillatory flow in a tidal river, no two-dimensional analytical solution to the coupled DO-BOD dispersive - decay equations have been found in the literature.

We therefore suggest a superposition procedure that treats each day's loading of BOD as an independent dispersing cloud. and gives an estimate of the oxygen reduction below the pycnocline at the site center as a function of time and resulting from a series of superimposed clouds. BOD decay and horizontal turbulent dispersion govern the dynamics of dissolved oxygen below the pycnocline in this model. Thus diffusion through the pycnocline and planktonic respiration and photosynthesis are neglected.

The basic equation for each day's "BOD cloud" incorporates the BOD decay rate k:

$$X = Q*\exp(-k*t)/(4*Pi*di*D*t)$$

Here the spatial terms have been neglected, since the oxygen deficit near the site center is of interest. Since the benthic terms often govern in the computation, a value at one point is a fair indicator of values over a wider area. For a discrete time step dt, the BOD concentration near the site center after a time n*dt is given by

$$X(n) = [Qb/(4*Pi*di*D)] \sum_{j=1,n} [\exp(-k*j*dt)]/[j*dt]$$

Where

X(n) = central BOD concentration (mg/l) after n days

Qb = BOD mass loading rate (g/release)

k = BOD decay rate (per day; calculated for Equation 6-1)

di = distance from bottom to pycnocline (m)

D = dispersion coefficient = 0.1 m^2/sec

= 8640 m^2/day

dt = computational timestep (1 day).

The summation above can be viewed as the superposition of n two-dimensionally dispersing clouds of BOD, released on successive days, or as n snapshots of a single cloud followed through time from release (t=0) until a time n*dt, when the cummulative sum of the central values is equal to X(n).

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3. FINAL TASK GROUP REPORTS

3.1 Exposure Methodologies

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Introduction

Physical characteristics of a dredged material disposal site important to site selection are those which determine the distribution of solids and dissolved chemicals derived from dredged material. Initially, when dredged material is released from a vessel its behavior is controlled by the discharge method and bulk material characteristics. In the Northeast U.S., material is usually obtained in clam-shell dredges and spot-dumped from scows. Under these conditions it has been found that more than 95% of the total material reaches the seafloor within 200m of the release point.

Along the Gulf of Mexico coast ocean-dumped material is dredged and dumped using hopper dredges or pipelines. The observation that material does not accumulate at the Gulf dump sites may be related to those dredging and discharge techniques. Initial behavior, however, is not a characteristic of the dump site. The necessary site-specific considerations are those which control transport of material away from the site and resuspension at the site.

Stage 3, "Transport Mapping and Resuspension Estimation", of the existing protocol is a first approximation to formulating the information needed to characterize and distinguish among sites on those bases. It essentially is a framework from which the flux of material from the site can be calculated and its subsequent distribution estimated. If, as may occur at Gulf sites, there is not settling of material at the site the flux of interest is simply the input rate of material. At Northeast sites, however, it is critically important to consider resuspension processes. In either case it is assumed that material within the site is of no environmental concern (the site has been written-off for other purposes).

Our deliberations and report are a refinement of Stage 3 of the protocol. We have recommended methods for using available current speed and direction data so that uncertainties are explicitly acknowledged and sensitivity of calculated results to ranges in input data is itself calculated. We have modified the protocol so that it more rigorously incorporates the effects of infrequent storm events on resuspension. In some cases it may be that these episodes account for most of the material flux. We have slightly modified the parameters used to characterize horizontal dispersion and explicitly included particle settling in the dispersion equations.

Prior to detailing those recommended changes two refinements of the problem description should be indicated. First, in terms of important vertical regimes within the water column the transport of deposited dredged material away from sites occurs in the benthic boundary layer. Consideration of the upper mixed layer, thermocline, and below is of interest when dispersion occurs away from the bottom. With deposited dredged material, however, dispersion occurs primarily within the near bottom region consisting of the upper 20 cm of sediment and over the vertical water column section within about 5m of the sediment-water interface.

Secondly, it should be explicitly stated that the calculations of the protocol will always predict more dispersion of sediment than will probably occur (a conservative prediction if dispersion is undesired). This results from there being no general, non-empirical, way to account for the fact that sediment particles do not behave as individuals. Protocol calculations are based on settling rates and resuspension velocities which apply to sands, silts, and clays under the assumption that there is no cohesion among particles. In all natural sediments there is cohesion, and particles settle faster than they would as individuals and cannot be as readily dispersed. Furthermore, cohesive sediments cannot be as readily resuspended as abiotic, loose assemblages of individual particles.

Comments and Recommended Modifications on Use of Current Data

In general, currents are a major factor governing resuspension and transportation of dumped materials. Currents may be variable over a wide range of space and time scales, and available data are often inadequate to compute statistically reliable averages. Hence a certain amount of judgement is required, and the current variability should be explicitly acknowledged through calculation of a probable range of current speeds and directions. These will serve as primary indicators of uncertainty.

Form DSP5 should be accompanied by instructions describing the methodology for determining currents, for several levels (tiers) of data quality and analysis sophistication. Addition factors to be considered in applying the current estimates should be spelled out in the main body of the protocol, examples are described below.

The tidal current components of the total current are usually estimated separately, since they have shorter time scales and are more predictable than longer-period current variability. For the purpose of this protocol, the mean current is defined as the average velocity over the time interval of interest; no attempt is made to account for variability on shorter time scales. The mean current is generally more difficult to estimate, since currents usually vary on long time scales (seasonal or longer) and on short spatial scales (often topographically controlled). In particular, care must be taken in extrapolating from single-point (moored instrument) measurements to trajectories over a spatial area. If drifter-type current measurements are available, they should be used preferentially, since they provide spatial information. If only moored current data are available, the apparent waste displacement that would result from the mean current speed acting over the time period of interest should be calculated, If this displacement is comparable to or greater than the distance to the shore or other region of interest, or if comparable to the size of major bottom topography irregularities, then it is probably incorrect to assume that the mean current is uniform in space.

Current Variability

A key concept that should be described in the protocol is the method of dealing with uncertainty in the current estimates. An estimate of a physical parameter is valueless without, at a minimum, an estimate of its probable range, and this is as necessary for the lowest tier of analysis as for the highest. The basic approach is

1. Estimate the mean vector velocity from best available data. An order of magnitude guess is acceptable for the simplest analyses.

2. Estimate the variability along maximally uncorrelated directions (not necessarily parallel and orthogonal to the mean vector). Crude "guesstimates" are acceptable if data are lacking, root-mean-square values based on current spectra are preferred. In any event, variability on wind-driven time scales (2 to 10 days) and seasonal time scales (30 to 365 days) should be addressed at a minimum.

3. Combine the mean and variability estimates into a set of 4 or more "probable" mean current vectors. This amounts in essence to defining a low-frequency variability ellipse, as shown in Figure 1.

4. Then combine these cases with estimates of the tidal ellipses, and eliminate intermediate cases to yield approximately 4 cases representing total current vectors in different directions. If a shoreline is present, a total current vector toward the shoreline should be among the cases.

Resuspension Probability Under Episodic Conditions

To permit evaluation of the relative importance of resuspension produced by the mean annual wave regime vis-a-vis that induced by the less frequent but more energetic extreme storm event two procedures are to be followed. The first calculates resuspension probability associated with long term average wave conditions while the second is concerned simply with the magnitude of resuspension and associated wind driven circulation produced by a single selected extreme storm event. Calculations associated with mean annual conditions are in the protocol.

To calculate the magnitude of probable resuspension associated with an extreme storm event the "design wave" concept is to be used. Within this concept selection of a storm having a recurrence interval of 100 years is recommended. To calculate the extreme wave associated with a storm of this intensity:

1. Using the percent occurence table of wave height versus wave period for the specified site (Table C-3 or equivalent) calculate the mean of the probability distribution and the significant wave height (H 1/3) associated with the distribution.

2. Using a simple scaling procedure (U.S.A.C.O.E. 1975) extrapolate these values to obtain an estimate of the height and period of local waves associated with the 100 year storm event.

3. Using the maximum wave characteristics, calculate the resultant near bottom velocities using simple linear theory. With these velocities enter Protocol Figs. C-11, C-12, and C-13 to estimate mass transport rate Q for the respective fractions of sand, silt, and clay present in the specified dredge spoil. On the assumption that the characteristic duration for the extreme storm event is 24 hours and that resuspension occurs uniformly across the dump site of width B, this rate can be converted to a mass flux Qf using:

$$Qf = (Q \times B)/365$$

To calculate the magnitude of the wind driven currents associated with the design storm event use the method of Bretschneider (U.S.A.C.O.E., 1975). This method directly yields current speed. Associated flow direction is assumed to be essentially parallel to the longshore bathymetric contours within and adjacent to the study area.

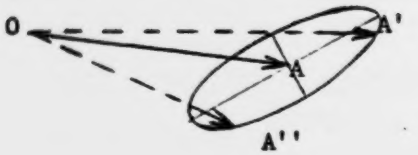

Figure 1. Vector OA represents the long term mean non-tidal current speed and magnitude. The ellipse shows the low passed variability, so that OA' and OA'' are equally likely to be encountered.

Horizontal Mixing

The mixing effects for use in the calculations are represented by dispersion coefficients, Dx and Dy, in the x and y directions, respectively. The initial mixing that actually occurs should be independent of site due to the relatively small scales which control the mixing processes in the immediate vicinity of the disposal site. Using Okubo (1971), a dispersion coefficient of 10^4 $cm^2/$ sec (with Dx = Dy) is appropriate for scales on the order of kilometers.

If the significant levels of the waste are dispersed further than a few kilometers, then more appropriate dispersion coefficients for those length scales should be used. The method described in the protocol using tidal excursion length scales is adequate for this purpose.

Two-Dimensional Discrete Cloud Model

A. Point Source (in water column only)

Use procedure exactly as in protocol. Note that the solution is valid for material that predominantly remains in the water column over the calculation region.

B. Point Source (with deposition)

To account for flux out of the water column to the sediments and to calculate the resultant concentration distribution in the sediments, the model has to be modified to include a deposition (or decay) term. The solution that would result would give the concentration distribution in the water column as a function of time and the concentration in the sediment as a result of deposition as a function of time.

An example of a possible solution to use could be as given by Csanady (1973) which was determined for deposition on a horizontal surface in atmospheric transport. The major limitations of this solution are that it is unbounded in the direction away from the horizontal surface and it assumes an initial source at a height, h, above the surface.

The major problem in using the model will be in the estimation of the proper settling velocities to incorporate. A series of calculations should probably be done with the major size classifications as used in the rest of the protocol. These calculations will give estimates of where the different size classes of material would deposit out.

In addition to these major points, the exposure methodologies group annotated small changes on a copy of Stage 3 of the protocol that was given to the authors.

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3.2 Hazard Assessment: Exposure

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The task of the Exposure Section of the Hazard Assessment Group is to provide the linkage between Exposure Assessment Methodologies and Effects Assessment. The purpose of a Tier I assessment is to allow a simple calculation to be made that establishes the maximal exposure concentration at a particular site for the composition of the waste to be discharged at that site. The intent is to compute the upper bound exposure concentration both in the water column and in the sediment via the four exposure routes considered below. The Tier I procedure is not intended to estimate a "realistic" exposure but rather the exposure that cannot be exceeded. Thus a secure upper bound concentration exposure is obtained for each constituent of interest. The severity of the effects associated with this exposure is judged by comparison to appropriate water and sediment quality criteria. If these concentrations are below the appropriate criteria, then the Tier I analysis assures that there will be no deleterious effects.

If the Tier I analysis indicates that the maximal exposure levels are above the criteria, no conclusion can be drawn as to the level of impact that the material will have. Rather an analysis which reflects more realistic assumptions, rather than the maximal exposure assumptions, needs to be performed. This analysis is termed Tier II.

The comparison of the dissolved contaminants in the water column with the acute or chronic Marine Water Quality Criteria (MWQC) for those chemicals is justified on the basis that the MWQC are derived from a large data set generated by standardized, accepted test methodologies. The minimum data requirements for an acute value mandates that several phyla be used to insure that the value is broadly representative. The acute value is one that should not be exceeded or for which the risk of adverse acute effects is great. The acute value is intended to protect 95% of a group of families of similar sensitivity as those tested. Chronic criteria are concentrations that can be safely tolerated for long term exposures. The choice of the appropriate criteria, acute or chronic, depends on the time scale, short or long, of the exposure being evaluated.

Both the Tier I and II calculations require physical transport models. The existing protocol uses the approach of first defining the chemical composition of waste materials (quantitatively and qualitatively), then applying a simple physical transport model to determine the waste distribution in space after a given time, and finally calculating whether the resulting waste concentration outside the disposal site will exceed an appropriate EPA criteria (water or sediment quality criteria). This approach requires direct linkage of a specific, well characterized, waste with a specific site on a case by case basis. This approach fails to separate the disposal site selection process from the permitting process. After considerable discussion, we concluded that it was critical to make such a separation at the Tier I level, if possible. One way to accomplish this is to invert the problem and ask how much waste can a given disposal site hold without water or sediment quality criteria being exceeded outside the dump site. In order to do this, the existing protocol physical dispersion model should be used to calculate a series of water quality isoclines around the point of discharge of the waste materials. The maximum amount that the site can receive will be the amount of waste that results in the co-occurence of the waste quality criteria isoclines with the site boundary. However, the isoclines are dependent not only on the physical dispersion at the site, but also on both the quantity (m of waste/unit time) and the chemical quality of the waste (chemical mass/m of waste). Since both quality and quantity are unknown (unless specific waste is considered), the equation can be solved by using a unit chemical loading rate (chemical mass/unit time). Once the maximal loading rate is established, the quantity of any waste of a given chemical composition can be calculated.

Through the application of this general approach it should be possible to compare different sites for a single waste (of known volume and chemical quality) or for evaluating an existing historical site for its capacity to handle a variety of quantities and chemical qualities of waste materials. This entire approach however, is based on the ability to establish the relative toxicity of potential wastes (via chemical analyses or bioassays) and to establish water and sediment quality criteria. Water quality criteria clearly exist for some substances. However, sediment quality criteria are still in the development stage and water quality criteria do not yet exist for many substances in complex wastes.

A broad spectrum gas chromatographic/mass spectrometric (GC/MS) analysis and metal analysis of the waste should be conducted for priority pollutants or other pollutants that might be expected based on the origin of the waste material. These analyses are needed in Tier I to determine the extent to which the material is contaminated. It cannot be assumed that the waste is clean even if it is dredged sediment from a "pristine" area. The chemical extraction procedures used prior to GC/MS analysis and those used for metal analysis are assumed to be the maximum extractable quantity of the contaminants that could be available to living organisms. If true, these analyses provide a first estimate of the upper bound of bioavailable chemicals.

Tier I

The Tier I exposure assessment protocol is designed to be an initial step in site designation and requires an absolute minimum of information about the site and the waste. The protocol is intended to be conservative in terms of assuming all waste materials are bioavailable, yet at the same time trying to take advantage of our ability (re: physical model) to estimate dispersion at the site so as to reduce effective exposure. These calculations are designed to set upper boundaries on effects through the application of the physical models and existing technology. If this analysis indicates no effects for the potential wastes at a given site, then no further action need be taken. If a given waste fails this analysis, then a higher tier of assessment is needed.

In Tier I, we will consider four exposure routes:

1. release into the water by desorption as the waste settles to the bottom following dumping
2. release into the water by desorption of resuspended sediments,
3. release into water by quiescent diffusive flux from the sediment and
4. direct exposure to benthic organisms living in the sediment.

1. Desorption During Disposal

For Tier I, it is assumed that all of the chemical components will desorb from the waste material and that all desorbed waste chemicals will be available to produce biotic effects. This defines the upper bound of possible exposure. The exposure of planktonic organisms will be calculated based on the concentration outside the waste dump site following post dump mixing and dispersion (calculated from the physical model and added to ambient background). These concentrations will be compared to acute water quality criteria.

2. Desorption During a Resuspension Event

For Tier I, it is assumed that all the waste present in a given area will be resuspended during the event and that all chemical components present (from all dumping activities at the site) will desorb from the resuspended material and will be biologically available. Since the physical model cannot estimate the spatial distribution of the waste, it must be assumed that all waste has remained within the site and that all of this waste will be resuspended into the water volume over the dump site. The resulting concentration (added to background concentrations) will be compared to acute water quality criteria. In calculating background concentrations, for a storm event, it is necessary to assume contaminants contained in the sediments outside the site (from all sources) will also be resuspended and will be equally bioavailable. An estimate of the probable time between resuspension events is required for this analysis.

3. Release Via Quiesent Diffusion

For Tier I, it is assumed that all of the chemical components in the waste deposited in one year will diffuse from the sediment over a period of one year and that all of the diffused mass will be exported from the site within that year (again using the physical model). Water column concentration outside the site are calculated based on the physical model. Dispersion of this material and all of the chemical constituents will be considered as bioavailable. The calculated concentration are added to ambient background and will then be compared to the chronic and/or residue water quality criteria. (Note: chronic and residue criteria are chosen here because of the long term, low level inherent nature of this type of exposure.)

4. Direct Exposure of Benthic Organisms

For Tier I, it is assumed that all of the waste material deposited in a year will be exported from the dump site during that year. Since mixing will clearly occur with uncontaminated sediments (to somewhere between 0.1 and 10 cm deep), it will be assumed that mixing occurs to a 1 cm depth.

The question to be answered is: what is the upper bound of the impact area outside the site. Once sediment quality criteria are established, the minimum allowable sediment concentrations could be established based on those quality criteria or residue limits assuming a bioconcentration factor of 10. The required areal extent of dispersion required to produce this concentration could be calculated. This would be the maximal impacted area for the following reason. Any smaller area will have higher concentrations but expose fewer organisms. Any larger area will result in a concentration below the minimum allowable sediment criteria concentration which, by definition, is not a problem.

In the absence of sediment quality criteria, a different approach must be used for estimating benthic exposure. In addition, mixing dilution with ambient sediments (mixing depth of 0.1 to 10 cm deep) may be very small relative to water column dilutions. We therefore recommend that a bioassay be run on the proposed waste. If the wastes do not pass the bioassay, Tier II is required.

Tier II

The purpose of Tier II analysis is to evaluate the bicta exposure which represents a more realistic assessment rather than the maximal exposure analysis performed in Tier I. Tier II analysis is meant to be reflective of the actual situation. The exposure concentrations calculated are not upper bound concentrations but rather an attempt to evaluate what the actual exposure would be. The procedure is divided into the four major exposure routes that were employed in Tier I.

The most important modification of the Tier I analysis to be employed in Tier II is that a quantitative experimental determination of the fraction of the total chemical concentrations which are available to the organisms is made. The chemicals chosen for analysis are those which exceeded the criteria using a Tier I analysis. These chemicals cannot be ruled out as causing a problem using a Tier I maximal exposure calculation. Therefore each of those chemicals must be subjected to a Tier II analysis.

1. Desorption During Disposal

The mode of release of chemical from the waste particles into the water receiving the discharge is via desorption. A direct experimental measure of the quantity of chemical desorped must be made. The procedure is to obtain filtered water from disposal site and to combine various volume fractions of water and waste that span the range of particle concentrations expected in the initial discharge, subsequent resuspension events, and quiesent diffusion. The desorption measurements should be made both in aerobic and anaerobic conditions. The desorption experiments shall be conducted so that the desorbable fractions of total chemical concentration can be determined. Since all chemicals may not be directly measurable, bioassays should be run on the highest concentration of leachate obtained.

2. Desorption During Resuspension Events

For this portion of Tier II a calculation method needs to be developed for water column dissolved concentrations to be expected during major storm resuspension events. It is suspected that significant quantities of accumulated waste materials are resuspended during rare but intense storms. The probability analysis in the protocol document makes an attempt at calculating the probable frequency with which such events occur. This calculation should be extended such that the exposure concentration in the water column can be estimated and compared to acute water quality criteria. Care should be taken to incorporate the fact that not only contaminated sediments will be resuspended but also the sediments in the entire area will enter the water column. Thus absorption to clean sediments should be considered as well as desorption from contaminated sediments.

3. Release Via Quiescent Diffusion

Chemicals may be released from interstitial waters to overlying waters by diffusive flux, augmented by the benthic biological activity. In order to calculate a more realistic flux the concentration in the interstitial water must be considered. A vertical one dimensional interstitial water diffusive model similar to the mixing depth model given in the protocol can be employed for this calculation. The partition coefficient between the sediment particles and the interstitial water, the diffusion coefficient of interstitial waters and the porosity are combined to predict the flux to the overlying water.

This flux is then used to calculate the chemical concentration in the overlying water using the methods of Tier I. The concentrations are compared to the chronic and/or residue water quality criteria as before.

4. Direct Exposure of Benthic Organisms

In the Tier I analysis it is assumed that the total amount of deposited material on an annual average basis would be transported out of the discharge site and into the surrounding sediment. At Tier II level of analysis the calculation outlined in the protocol document allows an estimate to be made of the annual amount of sediment transported out of the site.

Tier I analysis employed a mixing depth of 1 cm. A refined estimate can be made using the mixing depth model of the protocol document to calculate the mixing depth to be expected. At this point the calculation proceeds as in Tier I. The area of deposition is calculated corresponding to either the sediment quality criteria or, if that does not exist for the chemical, than an organism body burden (EPA action level) criteria. A measured biological accumulation factor is employed. The area that is calculated represents a more realistic estimate of the maximum impacted area beyond the disposal site.

The mass flux to the sediment to be used in this and the previous calculations should be decremented by the quantity of mass lost via water desorption calculated above.

Tier I Uncertainities and Research Needs

The level of resolution of the physical models which form the basis of the exposure calculations are, at present, unknown. Since the analysis is heavily based on the use of these models their level of resolution and degree of description of field phenomenon must be established. Full verification of the computed chemical concentrations must be accomplished as a first priority. Carefully designed experiments are required for this evaluation.

The method of judging the degree and/or extent of potential problems to be encountered are based on water quality criteria. At present, the degree of protection afforded by not exceeding these concentrations is unknown. This problem is not unique to the ocean disposal activities but is, at present, an important issue for all water quality investigations. We recommend that this issue be examined in detail.

The lack of sediment quality criteria and/or linkages between body burden and effects in benthic organisms severely hampers the ability to evaluate increases of concentration in sediments due to ocean disposal. Procedures for generating sediment quality criteria should be developed, and studies that investigate the residue - effect linkages should be pursued.

The exposure pathway that was not considered in this exposure assessment protocol was the possible export through food chains that involve organisms feeding on contaminated benthic or planktonic organisms. At both levels of resolution, Tier I and Tier II, computational procedures should be developed which enable an estimate to be made of magnitude of this export flux and its possible impact on the fish populations.

The use of any assessment methodology which is based on concentrations of known chemicals is subject to the uncertainty associated with chemicals which have not been identified and which may pose a potential problem. Additional uncertainty is induced by the fact that these wastes are composed of many potentially toxic components all potentially interacting in unknown ways. The sediment bioassay requirement in Tier I to some extent may mitigate this problem.

Data Requirements for Tier I

The fundamental information upon which the analysis is based is a quantitative estimate of the chemical composition of the waste material. A GC/MS Scan and the EPA priority pollutant list of heavy metals should be measured for several representative composite samples of the proposed waste material.

In addition, the data required to calculate the transport, used as input to the physical models, are required.

Tier II Uncertainties

Tier II has all the uncertainties of Tier I plus those imposed by a greater dependence on the validity of the physical models and by a dependence on the validity of the partition coefficient determinations. The more complex and data intensive models used for the transport calculations require field validation in order to establish validity. In addition, the methods used to quantify desorption, both quantities and rates of desorption, must be determined and validated as being suitable representations of these phenomenon.

The additional model requirements for resuspension and deposition involving the probabilities of occurences and the correct representation of adsorption and desorption during these events must be developed and field verified.

The uncertainties and therefore resulting sensitivities of the calculation to these uncertainties must be performed with more care than in the Tier I evaluation because Tier II is an attempt to calculate realistic concentrations rather than maximal concentrations. Therefore, a systematic estimation of probable uncertainty ranges of coefficients and their impact upon computed exposure assessment concentrations should be performed.

Data Requirements for Tier II

The additional physical transport data required to calculate the resuspension event probabilities and associated chemical concentrations are required in this tier. Additionally, the data required for the mixing depth model and the sediment flux diffusion model are required.

Since a major additional step in this tier is to quantify desorption extent and rates, the associated data for this mechanism are required.

All other data requirements are as in Tier I.

3.3 Hazard Assessment: Effects

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Level I - Biological Characterization for Site Designation

I. Introduction

The first step in Tier I, effects assessment is to define the spatial and temporal scales over which biological responses are to be measured and then to select those responses that are appropriate to those scales. The responses are then coupled to the predicted exposure field calculations for the whole waste and for its toxic constituents. This allows for a first order "upper boundary" estimate of hazard resulting from a specific waste being exposed at a specific site.

For the purposes of site designation it is important to identify the assumptions in Tier I hazard assessment since this will determine the quality and quantity of the data collected. The first premise is that data on biological effects must come from existing sources thus entailing a minimum of new data generation and analysis. Second, the spatial and temporal scope of Tier I calculations are near-field and short-term respectively. We are attempting to define biological effects spatially in three compartments. Effects data for the water column is provided by EPA-Marine Water Quality Criteria for individual priority pollutants contained in the proposed waste. The effects measurements are acute toxicity and chronic toxicity measured as bioaccumulation and employs FDA action levels as the regulatory benchmark. The bioaccumulation data also satisfies a second environmental compartment, the biota. The third compartment is the sediment which presents special problems. Unlike the water column, we do not have an extensive sediment toxicity data base that links biological responses to sediment contaminants. For sediment toxicity therefore, we cannot develop causal links between effects and exposure as we can for water. Another assumption in Tier I calculations is that the predicted impacts are not intended to be realistic but rather an "upper boundry" estimate, that is a worst case situation defined by the maximal possible exposure concentrations of the waste constituents. Finally, in situations where direct causal links between exposure and effects are not readily available we will simply couple habitat and species maps with exposure field projections. Tier I calculations for acute toxicity and bioaccumulation derived from water quality criteria will be discussed in exposure assessment. This chapter on effects assessment will focus on the following areas: biological habitats of limited distribution, commercial and recreational fisheries and baseline tissue residue data from new and historical sites, the latter being necessary for calculating the incremental changes allowable using upper boundary residue calculations (Re: Exposure Assessment).

II. Biological Habitats of Limited Distribution

1. Are distinctive habitats of limited distribution (such as kelp beds or coral reefs) located in areas potentially affected by the dumped material? [40 CFR 228.6 (2) and (8)].
2. If yes, provide available information on types, extent, and location of habitats.

Available information should be used to describe all distinctive habitats of limited distribution identified in the vicinity of the dumpsite and in other areas potentially influenced by the dumped material. If no distinctive habitats of limited distribution exist within 16km, (10 mi) of the existing or proposed dumpsite boundaries no further analyses should be required.

Distinctive habitats of limited distribution include those marine environments whose protection is of special concern because of their ecological significance or value to man. These habitats include, but are not limited to, coral reefs, kelp beds, seagrass meadows, sites of productive fisheries spawning or nursery areas for commerical species, sites of aesthetic appeal to man and rocky intertidal habitats (where they are uncommon), and all areas recognized as marine sanctuaries.

Distinctive habitats of limited distribution may be highly susceptible to impacts from dumped material. The relatively high sensitivity of distinctive habitats results from the potential effects of dumped suspended solids and nutrients on the unique floral (e.g., kelp, seagrass) or faunal (e.g., coral) components of the communities. Moreover, the potential for adverse effects of bioaccumulation of toxic substances is also relatively high since sessile floral and faunal organisms may constitute important trophic pathways within these communities. These attached communities are also susceptible because of the potential for periodic exposure to the dumped material.

A general description of habitat types within the receiving water environment should be presented. Special attention should be given to the presence of distinctive habitats of limited distribution. The following information regarding distinctive habitats should be presented:

1. Kinds of distinctive habitats occurring in the general vicinity of an existing or potential dumpsite
2. Distribution of the habitat in the region
3. Approximate distance from the potential or existing dumpsite to potentially impacted habitats.

The basic information is expected to be descriptive in nature, and may not require field surveys. Possible sources for information on the distinctive habitats include:

1. Contacts with local offices of state conservation agencies.
2. Review of literature, especially resource maps available for many areas.

Since most distinctive habitats are visible to a surface observer, the use of direct visual observation of the marine environment in the dumpsite vicinity may be considered.

The primary emphasis of the discussion should be oriented towards an assessment of the potential for contact of the dump material with any nearby distinctive habitats. The minimum informational requirements would be associated with cases of which there are no known distinctive habitats in areas potentially affected by the dumped material. If distinctive habitats are identified in the region, the potential for significant solids deposition, other habitat modification or community alteration related to the disposal activity must be assessed.

In cases where a distinctive habitat occurs near an ocean dumpsite, evaluate impacts by considering:

1. Concentrations at various pollutant isopleths
2. Degree and direction of farfield dispersion
3. Frequency and direction of waste transport
4. Presence or absence of prior appreciable harm.

If available, additional important information which could be supplied include documentation of any long-term changes in spatial extent or general health of the distinctive habitat. Examples of such information would include areal extent of kelp beds or condition of algal cover on coral reefs. If historical changes in the habitat have occurred, an attempt to relate those changes to natural or pollution-related events should be considered. For example, coral reefs may be extensively damaged by severe storms, and trampling by heavy pedestrian traffic can impact rocky intertidal communities.

III. Commercial and Recreational Fisheries

Are commerical or recreational fisheries or other resource populations located in areas potentially affected by the dumped material? [40CFR 228.5 (a) and (b), and 228.6 (2) and 8]. If yes, provide available information on types,

location and value of fisheries.
Documentation of fisheries in the receiving water body is important because of economic and recreational aspects and because of the potential for human consumption of contaminated organisms. Available information to describe commerical or recreational fishery resources in the receiving water body should be used. Potentially important resources include molluscan (e.g., clams), epibenthic crustacean (e.g., crabs), demersal (e.g., flounder) and pelagic (e.g., salmon) fisheries.

Assessments of impacts on fisheries is important because of economic significance, recreational potential, and the potential for human consumption of contaminated organisms. For this assessment, the data should specify whether species of recreational and/or commercial importance occur in the following areas:

1. In the immediate vicinity of the existing or potential dumpsite.
2. In the general region of the existing or potential dumpsite.
3. As migrants through the region.

The immediate vicinity of an existing dumpsite includes the area encompassed by the coordinates presented in 40CFR 228.12 or which is clearly impacted by discharged sediment deposition. The spatial extent of fishery data will depend on the volume and potential effects of the discharged material and on the characteristics of the data. In general fisheries occuring within areas potentially influenced by the dumped material should be considered. Many state fish and game agencies have established coastal statistical areas for recording fisheries data. In this case, consider regional fisheries as those occurring in the statistical block(s) which include or are adjacent to the potential or existing dumpsite. If fishery resources in the receiving water body are identified, the distance(s) of the fishery resources beyond the existing or potential dumpsite boundaries should also be provided.

If fishing areas in the vicinity of the existing or potential dumpsite are identified, the following information should be provided:

1. Effort levels (e.g., number of vessels or number of fisherman)
2. Economic value of landings or sport fishery
3. Temporal pattern of the fisheries.

It should also be determined if any potential, unharvested fishery resources occur in the area due to warnings or closures. If unharvested resources are identified, the reason(s) should be determined why these resources are not utilized, including such aspects as:

1. Health related factors (including paralytic shellfish poisoning, bacteriological contamination, and bioaccumulation of toxic substances)
2. Economic or marketing considerations
3. Resource protection closures
4. Other regulatory closures

If reasons for closures are due to tissue contamination, the pollutant sources identified as contributing to the contaminant levels should be specified.

Many sources of information are available to address the fish and fishery concerns outlined above. Among others these groups should be considered as sources:

1. Local fisherman
2. Public, institutional, and agency libraries
3. Academic institutions (e.g., marine science, biology, zoology departments, Sea Grant offices, cooperative fishery research units)
4. Local (e.g., conservation boards), state (e.g., fish and game departments), and federal (e.g., National Marine Fisheries Service, Fish and Wildlife Service) natural resources agencies and affiliated laboratories.
5. Regional fishery management councils (contact information available from National Marine Fisheries Service)
6. State and federal environmental protection and public health agencies.

The informational needs, sources, and types of data available are summarized in Table 1. This is not an exhaustive listing but is meant to provide an overview of important considerations and the most likely sources and types of information which may be expected to be available for a given area.

IV. Bioaccumulation

Baseline residue analysis at Tier I are necessary to demonstrate the degree to which historic dumpsites have contributed to existing contamination, thus raising the baseline and decreasing the incremental additional allowable. Exposure field information, including a detailed chemical characterization of contaminants, predicted bioaccumulation values from upper boundary calculations are coupled with the background residue values for indigenous species and compared to FDA action levels.

The ocean dumping of materials containing toxic substances can result in bioaccumulation, especially in areas of organic sediment accumulation. The two general categories of substances with the highest potential for bioaccumulation in marine organisms are toxic heavy metals and persistent synthetic organic compounds. The identification of substantial concentrations of

TABLE 1. FISH AND FISHERIES INFORMATION NEEDS, SOURCES, AND TYPES

Information Needs	Information Source	Information Types
Background information on fish and fisheries	Libraries	Published literature, unpublished technical reports, and other "grey" literature
Characterization of fish community (species composition, distribution, abundance)	Academic institutions Natural resource agencies	Survey Data
Characterization of recreational and commercial fisheries	Natural resource agencies Regional fishery councils Academic institutions	Fishing areas, seasons, and regulations Effort, catch, and value statistics
Fish health (bioaccumulation, disease, mass mortalities)	Academic institutions Natural resource agencies	Laboratory analyses, survey data, fish kill reports
Public health considerations	Environmental and public health agencies	Closures, warnings, documented incidents, laboratory analysis
Economic/marketing factors	Federal and state natural resource agencies	Fishing regulations, market demands, prices and availability

such substances in potential material to be dumped in combination with any of the following receiving water characteristics indicates the need for evaluation of bioaccumulation:

1. Evidence of effluent transport towards areas utilized for shellfish harvesting;
2. Significant occurrence of important recreational or commercial species and evidence of potential sediment accumulation in the dumpsite vicinity;
3. Evidence of effluent transport towards biological habitats of limited distribution;
4. Previous history of contamination.

If the above conditions are not met, and/or dispersion is adequate, tissue analyses of indigenous biota may not be required to demonstrate the absence of adverse bioaccumulation. Dumpsites located in areas with limited dispersion, may cause contamination of local shellfish resources. In such cases, analyses of tissue concentrations of toxic substances identified in the potential material to be dumped, should be conducted. Examples of species which may be appropriate for tissue analyses include oysters, clams, mussels, crabs, or lobsters. An additional situation which will influence the requirement for direct assessment of bioaccumulations where other pollutant sources cause observed contamination of fish or shellfish resources. This would especially pertain to cases of nearby fishery closures or harvesting restrictions due to pollutant inputs. In such cases it is important to demonstrate that historic dumps have not contributed to the existing contamination. This demonstration can be accomplished by plotting dump material pollutant concentrations, pollutant concentration areal isopleths, or by evaluation of existing information on the spatial patterns of pollutant concentrations in organisms or sediments. It may be necessary to conduct tissue or sediment analyses if historical dump material bioassays indicate the potential for bioaccumulation and sufficient data are not available to determine pollutant sources in areas of existing contamination of fishery resources.

V. Summary of Level I Effects Assessment

Tier I calculations are characterized by upper boundary calculations of exposure conditions on a single contaminant basis principally for near field spatial and short term temporal conditions. Contaminant profiles are compared to acute toxicity and FDA action levels via bioaccumulation for dissolved materials (water column). Contaminant profiles are also compared to critical biological habitats and fisheries resources resulting in exclusion and or movement of disposal site. This mapping of habitat and exposure field does not constitute a causal effects-exposure linkage such as that described above for water quality criteria or FDA action levels. Developing an effects/exposure link with sediment presents unique problems due to the lack of sediment toxicity criteria and direct testing

(Tier II) is required. Finally, Tier I upperboundry predictions of contaminant uptake from sediment can be approximated and when coupled to field baseline residue values provides an estiamte of the potential incremental addition that is allowable from these calculations.

Level II - Effects Assessment

I. Introduction

The operational premise for Level I has been to utilize as much existing data as possible, to assume toxicity is mediated through the aqueous phase, develop exposure models that assume total release of contaminants into the aqueous phase, and to then compare acute, chronic, and bioaccumulation endpoints from the water quality criteria to the estimated maximum water concentrations. This approach results in an upper boundry estimation of hazard. Generally we are dealing with approximately a factor of 1000 estimate of error in the proposed comparison. That is, if the biological effects value is within 3 orders of magnitude of the maximum estimated water concentration there is a high probability of hazard. One could propose the following hazard triggers for Level I calculations:

Biological Response 1,000 Water Conc. = High Hazard
Biological Response 10,000 Water Conc. = Moderate Hazard
Biological Response 100,00 Water Conc. = Low Hazard

While the value of these numbers may be argued, they are useful in directing the scientist and regulator to more precise estimates of hazard through specific research avenues.

Tier II, Effects Assessment is an actual data generating and acquistion exercise designed to produce a more precise and realistic estimate of the relationship between the exposure concentration of pollutants and biological responses. Exposure field calculations are no longer upper boundary but "best judgement". The types of calculations for water column effects still employs the criteria but is expanded to include chronic as well as short-term effects and bioaccumulation. Development of effects information on the sediment will rely on direct testing - that is, it is site-specific for the waste and biota and includes acute, chronic, and bioaccumulation tests. This data is then compared to "best judgement" exposure conditions leading to a judgement on hazard. Tier II Effects Assessment also recommends the introduction of sediment toxicity tests into the assessment of degradation of existing sites. The approach parallels that for bioaccumulation and attempts to toxicologically define the potential incremental increase in toxicity required to reach an unacceptable level.

II. Water Column

Water Column Exposure/Effects relationships will be refined principally in the area of defining the probable exposure field for the priority pollutants of interest. The biological responses to be measured will again be taken from the water quality criteria, specifically the maximum short-term exposure concentration that produces no effect in 95% of the species tested. An alternative approach that is less restrictive is to utilize species specific toxicity data when available. The objection to this latter option is that the maximum criteria value is more protective of system level functions than the individual species approach which generally includes multiple trophic levels. Calculations of bioaccumulation (tissue residues) in water column species will be refined based upon improved predictions of pollutant exposure concentrations. This will lead to better estimates of residue values as they relate to the regulated FDA action levels.

The improvement in prediction of water column effects at Level II is principally a function of improved exposure assessments since the basis for the biological response will not have changed.

III. Non-Water Column Exposure

Contaminants will occur associated with both suspended particulates and sediments. While these contaminant sources were covered in Level I by assuming total aqueous release for the purpose of upper bounding calculations, at Level II there must be a direct estimation of toxicity at the acute and chronic levels from these two exposure routes.

The general recommendations for this section is to develop dose-response data bases for contaminants associated with suspended particulates and solid phases. In addition a similar data base is needed in the area of bioaccumulation. The development of these data bases will provide a more precise estimate of sediment toxicity and may lead to generic models of sediment quality. The refined relationship of chronic biological reponses and bioaccumulation to the suspended particulate and sediment contaminants can then be coupled to the exposure fields for these two contaminant phases to improve the predictions of hazard.

IV. State-of-the-Art Suspended and Solid Phase Testing

Current Ocean Dumping Regulations require an evaluation of the toxicity of the solid, suspended and liquid phases of wastes proposed for ocean disposal. Procedures for these tests were published by EPA/COE, 1977. However, the suspended phase tests are designed for water column, short-term acute exposures which are not the issue in this discussion of Level II testing. In this latter case we need to develop and apply methods for assessing the effects of chronic exposure on infaunal and epibenthic species, focusing on growth, survival, reproduction and bioaccumulation. These tests should probably be of 10-30 days duration. In the area of benthic bioassays, there have been substantial improvements in the procedures since the 1977 implementation manual was published. It is our recommendation that these tests be utilized to determine chronic sediment toxicity values and tissue residues via bioaccumulation processes from sediment contaminants.

V. Field Sediment Toxicity

Sediment toxicity surveys should not be required for all or even most disposal sites. They are useful in assessing impacts where the introduction of contaminants are likely to exceed the assimilative capacity of benthic ecosystems. The toxicity results reflect the overall level of stress imposed by all contaminants and interactions between components of complex wastes.

The two primary objectives for sediment toxicity gradient analysis require different survey designs. The first objective is to assess the spatial distribution of sediment toxicity. This "spatial" survey will indicate the distribution, (if any) of sediment toxicity, establish a baseline for new disposal sites, and contribute to the selection of stations (reference, dump site, dump site boundary, gradient, "hot spot") that should be monitored quantitatively during a continuing monitoring program. A major consideration in the survey design is broad spatial coverage. Samples should therefore not be replicated and the result should be a contour map of toxicity isopleths. As part of a site designation assessment, the spatial survey will provide one indication of the existing level of stress on the benthic ecosystem. As part of the post-designation monitoring program, the spatial survey will allow a comparison of exposure predictions and biological effects.

The second objective of sediment toxicity gradient analysis is to statistically test the hypothesis that sediment toxicity does not change in time or space. A minimum of three stations are necessary: 1. dump site center, 2. dump site boundary and 3. non-toxic (or baseline toxicity) reference station. Policy decisions may base regulatory actions only on comparisons between the dump site boundary and reference stations. However, the dump site center station is highly recommdended so that the toxicity of dredged materials (and other wastes) tested before disposal as part of the permit process can be compared with toxicity after disposal. This is a field validation of the permit test that has permit specific and general relevance. Additional stations should be established, as appropriate, along gradients between dump site where wastes are expected to accumulate. The null hypotheses of no difference in sediment toxicity between stations can be tested in space or time to determine if sediments at the dump site boundary have been contaminated to the extent that they are acutely toxic. Toxicity data can be correlated with biological or contaminant distributions to indicate causal relations.

Since sediments are the ultimate sink for any contaminants, benthic bioassays can indicate the toxicity of sediment in the receiving environment for dredged material, sewage effluents and any waste that impacts benthic ecosytesm.

There have been substantial improvements in benthic bioassay procedures since the 1977 (COE/EPA) implementation manual was published.

Test species for the bioassays should include the more sensitive, indigenous species. Infaunal amphipods are recommended. Replicate samples (at least 5/station) are necessary for a realistic and precise statistical test. These should be true replicates, not composite or sub-samples. Since the spatial distribution and degree of sediment contamination is usually a function of long-term accumulation, annual benthic toxicity surveys should be sufficient to detect temporal trends.

VI. Summary of Level II Effects Assessment

The approach recommended in Level II is to conduct waste specific acute, chronic, and bioaccumulation tests and to couple biological responses to actual contaminant levels in suspended particulate and solid phases and to compare these values to refined predictions of field exposure conditions resulting in an improved hazard assessment.

Water Column

Exposure concentrations redefined - best judgement
Short-term toxicity data from water quality criteria

A. The maximum criteria value which is the no effect concentration for 95% of species after 96 hours of exposure.
B. Species specific acute toxicity data for priority pollutant for critical species in the site.

Chronic toxicity data from water quality criteria:

A. The 24-hour chronic value which protects 95% of species from chronic effects;
B. Bioaccumulation, FDA action levels from water quality criteria.

Suspended Particulate Contaminants

Suspended particulate contaminant distributions.
Acute and chronic methods to determine dose response relationships to be compared with environmental exposures.
Bioaccumulation methods for determining tissue residues

which can be compared to FDA action levels.

Sediment Contaminants
Distribution and quantification of priority pollutants in sediment
Utilize sediment phase toxicity tests to determine chronic sediment toxicity (dose-response relationship) of specific wastes and compare this value with exposure field predictions to estimate hazard.
Determine tissue residues resulting from bioaccumulation tests with sediments and compare to FDA action levels.

Recommendations

As a result of workshop discussions, it was recommended that, in addition to initial biological site characterization for (a) habitats of limited distribution and (b) commercial and/or recreational fisheries, a characterization of the benthic community was deemed necessary, particularly for existing sites, to determine the extent of degradation.

Two problems were identified:

(1) Had the existing community degraded as the result of historical practice? (2) If so how could we assess this? Community gradient analysis using structural indices (Pearson/Rosenberg, Gray's log-normal, Rhodes, etc.) was suggested. A second approach was to develop sediment - biotic contaminant gradients. A third approach was to utilize sediment toxicity bioassay along a gradient.

-The group strongly recommends the re-convening of the joint - EPA/COE committee which worked on the dredged material implementation manual.

The following were highly recommended research areas:

- Develop models and criteria for relating sediment contaminants to biological effects, i.e., Sediment Criteria
- Develop methods for predicting and determining the qualitative and quantitative aspects of bioaccumulation from contaminated sediments.
- Determine the relationship (causal) between tissue residues of contaminants and biological responses, which is the relationship between body burden and effects.
- Field verify the methods to determine the confidence range of lab predictions.
- Finally, there is a need for a well conceived and designed monitoring program that is implemented from the time of designation.

REFERENCE

U.S. EPA/COE Technical Committee on Criteria for Dredged and Fill Material, "Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters, Implementation Manual for Section 103 of Public Law 92-432 (Marine Protection, Research, and Sanctuaries Act of 1972)." July 1977, published by the Environmental Effects Laboratory, U.S. Army Engineer Waterways Experiments Station, CE, Vicksburg, Mississippi.

3.4 Policy Issues In Site Designation

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The group was asked to examine the draft protocol and to evaluate the likely role of its individual components in the site designation process. In order to accomplish the task, the group found it beneficial to consider the site designation stage in the context of the whole approval system, from the initial search for a possible dump site to the issuing of a special permit and conditions of use and monitoring.

Dump site designation is considered to be part of a continuum that ranges from an initial, subjective evaluation (candidate site identification) to a rigorous, quantitative, and highly structured process (special permit evaluation). The group views elements of the existing draft protocol as being applicable to both the site designation and special permit evaluation stages. In addition, the group feels that the protocol may be useful in identifying those issues that must be addressed in dump site management.

The group considers that the steps necessary in both the site designation and special permit evaluation are similar Because of the specific nature of the data required for the special permit application, this stage should be the more rigorous and quantitative and, ultimately, capable of being defended in court. The site designation process could thus be regarded as a precurser to the key regulatory stage of the special permit evaluation and should be semi-quantitative and flexible, reflecting the inherent limits on data availability arising from the generic nature of the exercise. From an operational point of view, it could thus be more practical to link the formal site designation stage with the special permit application rather than to regard it as a separate regulatory act.

Prior to considering the applicability of each stage of the draft protocol, the group clarified the steps necessary for the selection of candidate sites for the site designation protocol and drafted the preamble to the protocol in the Policy Issues Appendix. The group also identified two general principles to be considered when applying the draft protocol.

First, assumptions regarding aspects of the protocol such as waste loading, characteristics of the dump site should be conservative but realistic.

Second, attempts should be made at each stage to identify the degree of uncertainty in the assessments at each stage. This should lead to a sensitivity analysis to identify key variables whose accuracy is essential to the validity of an decision to designate the site.

Specific comments on the individual stages of the draft protocol are presented below:

STAGE 1 Preliminary Site Evaluation

This stage of the evaluation should reflect factors considered as part of the candidate site selection process described in the preamble (Appendix A). As such, primary siting conflicts with the use of the sea specified in Section 228.6a of the Ocean Dumping Regulations should be avoided.

STAGE 2: Waste Profile and Loading Characterization

The estimates necessary for site designation should be based on the most probable composition of the waste.

STAGES 3 and 4: Transport Mapping, Resuspension and Source Strength Estimates

The object of the Site Designation Process is to determine whether or not a candidate site is likely to be suitable to accept the estimated type and volume of waste. The question then becomes: How much of what waste can be put at the site? In order to make this determination, estimates of the impact field must be made by utilizing both physical tranport and dispersion. Stages 3 and 4 address this portion of the issue.

In the Site Designation Process it is understood that informed estimates of physical processes must be utilized. For instance, reasonable predictions of the transport and dispersion of particulate matter can be made, but highly accurate ones are impossible due to data and/or theory limitations, e.g., cohesive sediment behavior. The estimates of transport and dispersion must, however, be qualified relative to the parameters utilized in the calculations, e.g., time scale of the currents - average for one week, one year, etc.

Predictions of the fate of suspected contaminants utilizing available area-specific data, literature or other appropriate data (e.g., from other relevant site studies) are acceptable. It may be necessary to conduct field studies to obtain needed but missing information.

STAGE 5: EPA Water Quality Criteria Comparisons

The Sub-Committee has found that Water Quality Criteria may not be appropriate for the Site Designation Protocol. The reasons center about the uncertainties in the exposure assessment. These include:

a. the imprecision in waste composition
b. the lack of knowledge of partitions, and
c. the lack of data on chemical specications.

An alternative may be the use of whole waste bioassay data. Such data would be selected based on the generic characteristics of the waste typically to be disposed.

In the use of bioassy results chronic toxicity data would be preferable to acute where available, appropriate safety factors must be applied.

The use of bioaccumulation data is discussed under Stage 7.

STAGE 6: Estimate of Hypoxic Events

Due to the infrequency of hypoxia related problems associated with disposal operations, the Policy Group has concluded that Stage 6 of the protocol (Estimates of Hypoxic Potential) is not required in all instances. Stage 6 should be implemented in those cases where there is a history of and/or a reasonable potential for hypoxic events.

Stage 7: Species-Specific Assessments

The Policy Issues Sub-Group recommends that priorities implied in the present protocol should be reordered. The primary purpose of Stage 7 is to consider the impact of exposure fields on important resources, specifically, harvestable living resources and protected/endangered species. Evaluation of impacts should give consideration to both toxic effects and bioconcentration of contaminants in organisms harvested for human consumption. Consideration of impacts on non-harvestable species will occur in the permitting process.

Stage 8: Verification

Key assumptions identified in the site designation process should be verified as part of the permitting/site management process.

POLICY ISSUES APPENDIX: SUGGESTED PROTOCOL PREAMBLE

This protocol for ocean dump site designation starts with a primary entry point which presumes that a candidate site has been identified by some preceeding process. The nature of the identification process is not envisioned as a rigorous, formalized activity. Nevertheless, it must proceed with some structure to ensure that essential criteria are considered. The minimum requirements of the candidate site identification process are discussed below.

A candidate site will be identified for a generic type of waste (e.g., dredged spoil, sewage sludge, fly ash). In general the effort to identify a candidate site may be considered in three stages. The first phase involves placing boundaries on the search area. This may be determined by economic or technical considerations such as the location of the port of loading and maximum acceptable transit distances and times. Once the boundaries of the search area are defined, the effort seeks to identify and eliminate those portions of the area that may be incompatible with dumping activities. Important features that should be considered include those listed in Annex III of the London Dumping Convention and in Section 228.6a of the EPA Ocean Dumping Regulations and Criteria. These include avoidance of interference with navigation, beaches, migratory routes, harvestable resources, sensitive stages of fisheries (spawning and juvenile areas), marine sanctuaries and other legitimate uses of the sea. Also eliminated might be areas that are impractical for consideration for jurisdictional reasons.

The third phase selects and ranks potential candidate sites from the area that remains for consideration after phase two. Factors such as the availability of existing data bases, the broad features of the physics, geology, and chemistry of the search area, and the general characteristics of the wastes likely to be disposed are brought into consideration at this point. For example, if the wastes slated for dumping are contaminated with toxicants, sites that maximize dispersal or maximize the possibility of containment may be sought, depending on the properties of the wastes to be disposed.

The candidate sites selected by the above process will often be historical sites, if only because any adverse impacts (e.g. burial by spoils) have been accepted by the interests affected and because more data are available on such sites. In other cases, it may be possible to identify more than one site offering the potential to minimize adverse impacts. In such a case (e.g. where the candidate sites differ in their dispersive capacities) more than one site may be put forward for more detailed consideration via the full site designation protocol.

The above assumes that other factors such as the availability of alternative methods of disposal, although outside the scope of this protocol, will be considered.

4. TUESDAY EVENING PLENARY SESSION: GROUP PROGRESS REPORTS

4.1 Group I: Exposure Assessment Methodologies

Reporter: Thomas P. O'Connor

I think our job, although not simple, is the easiest. It has been a matter of going to the protocol and refining it. First of all, we were not concerned with initial mixing. It is a practice in the United States to dump dredged material quickly from barges in shallow water. It goes to the bottom quickly and piles up on the bottom immediately. The distribution of material behind the barges is of consequence when dumping sewage sludge or industrial wastes behind slowly moving barges. It is not of consequence for dredged material. So the pile of dredged material that is on the bottom at these dump sites is a source of contamination, and the questions are in terms of differentiating one site from another or characterizing a given site. What one needs to know to predict whether or not the material will be resuspended, or the contaminant release rates from the dredged material are in the protocol already. Resuspension and transport are the basis of our deliberations. The results of our deliberations will involve modifying the protocol.

One thing we should emphasize, as is listed in the protocol now, is that we assume that particles will behave individually. We acknowledge that particles have a cohesive nature and do not act as individuals. Thus, particles that adhere to each other may fall more quickly than individual particles and, they are less likely to be resuspended than individual particles, but there is no reliable analytical way to deal with that fact. So we are overestimating the dispersion of dredged material from dump sites. There is no way around that. We do wish we had some documented experimentation with dredged material from the Gulf of Mexico, where 90% of the ocean dumped dredged material in this country goes, and we are told that none of it piles up at the dumpsites. We do not know if the dispersion is because of the tidal velocities, wind velocities, or what have you in the Gulf Mexico, or because of hopper dredges tends to liquify the sediment at the time of dredging. So we would like to include some Gulf of Mexico experience in the protocol, since that is where most of the dredging is done. What we are modifying in the protocol is what should be done when you do not know the mean velocity or you do not know the tidal velocity. What does one do in the absence of such data? What best estimates can one make for those new values? We want to emphasize the importance of both transport magnitude, and trajectory. It could happen that if you dump close to a shore a beach could be impacted.

One thing the protocol does not deal with sufficiently is storm events. We want to modify the protocol to include the consequences of currents, high winds, and big waves with long periods and stronger velocities along the seafloor. The last thing that we want to modify in the protocol is the calculations for dispersion. The transport equations should include deposition of particles. We may change the diffusion coefficients a little bit, but that is no big deal. That is it. That is where we stand.

4.2 Group II: Hazard Assessment (Exposure Sub-Group)
Reporters: Victor J. Bierman, Jr. and Dominic M. DiToro

Vic Bierman: In the temporary absence of the chairperson for the exposure assessment subgroup, let me try to summarize their present position. We are trying to develop a Tiered Hazard Assessment Approach to make some estimate of the impact of the disposal of a specific waste at a specific site. That is where we are headed. The exposure assessment sub-group has in fact developed a version of a tiered approach for the estimation of the exposure environment. Conceptually, Level I is a fairly simple level which makes simple conservation and dilution assumptions, for which one does not need a lot of data. There is very little field evaluation. At the second level, there is a series of refinements that are directed toward improving the assumptions of conservation, dilution, complete mixing, and so on. The second level of the approach to exposure assessment tracks very closely with the methodologies in the existing strawman protocol. The third level should involve site specific, data intensive, field validated calculations for source inventory, tracking concentrations in the water column, deposition, mounding, resuspension, transport, and redeposition. In Dominic's words, "Let's do the job right." (i.e. 2 or 3-dimensional physical transport models). That is an issue we need to resolve or we need to at least reconcile between groups 1 & 2. If Tier III is perceived in that way, it takes the analysis out of the realm of the non-specialists. So Tier III would require a specialist, whereas Tiers I & II could be done by the non-specialists. Tier I starts with the same conceptual approach that is built into the 1977 Dredged Material Implementation Manual developed by the Corps of Engineers and EPA. Those assumptions are that you dump the mass in a given receiving volume, and you calculate the intitial water column concentration by just taking the mass, dividing it by the volume assuming complete mixing, assuming conservation, and not making the distinction between available and unavailable components.

Dom DiToro: There is one thing you might want to say. The idea is that these Tier I estimtes are upper bound calculations. Things cannot be any worse than this.

Vic Bierman: It is really a mass balance that is done in three parts in series. First, the mass from a barge or series of barges is dumped into the water column and an upper bound calculation is made for the exposure concentration. That concentration can be compared against, for example, acute marine water quality criteria, the assumption being that most contaminants that would be associated with particulates won't be in the water column long enough to worry about 30-day chronic effects. Then you transport the entire mass down to the sediment, and the sediment concentration is calculated with all that mass. You just take the same amount of mass and move it down to the next compartment, and some assumptions are made on the distribution of it (I won't go into detail), and sediment concentrations are calculated. A bioconcentration factor is estimated and tissue residues in the infaunal organisms are estimated. If we had sediment criteria, we could compare the concentrations to the sediment concentrations. If we do not, the least we can do is compare the estimated tissue residues to the FDA action limits.

Finally, (keep in mind that we are tracking the same amount of mass) there is another pathway of concern. We make the simplistic assumption that over an annual cycle all this mass that we have collected in the sediment diffuses out, and converts to a dissolved form, an available form. Again, it is an upper bound type of calculation. The worst that could happen is that over a year's time, all of the accumulated constituents could diffuse to the water column. Since this is the process that takes place over a longer period of time, what you are doing now is calculating a water column concentration via this third exposure pathway, and you can compare this again to EPA water quality criteria (acute if you want, but probably chronic would be more appropriate over a longer time period). You would end up with lower concentrations in the water column because you have got the mass spread out over a bigger area.

So to summarize the very simplistic set of calculations, the worst that can ever happen in the water column is you dump the mass in the water column, assume all constituents are available and calculate a concentration. The worst that could ever happen in a sediment is you run all this mass down to the sediment and calculate your concentrations. The worst that could then happen again is that all this mass comes boiling out, you then calculate your water concentrations. As far as ranges of uncertainty, by definition it is the worst case upper bound estimate given very little data. The actual concentrations that will occur of course will be lower. By how much? 1,2,3 orders of magnitude, it is anyone's guess. It is a very simplistic calculation.

Tier II--what is the difference between Tier I and Tier II. The weakest point of the Tier I analysis conceptually is that you assume that all the mass is available. In fact we are talking about coupled contaminant-particulate systems. Not all the mass of the contaminant you dump is available. In Tier II, the notion of partitioning to particulate material is then introduced and the distribution of the contaminant into particulate and dissolved phases is explicit. There is more explicit consideration of settling, there is explicit consideration of the mound as a secondary source through resuspension, transport, and redeposition. And the second tier follows basically the equations in the present version of the Protocol but with the stipulation that you either have, or you gather, the data to support these calculations. These calculations are more realistic in terms of contaminant fate and in terms of contaminant partitioning. As I mentioned, the first two tiers are capable of being implemented by the non-specialist according to a well-defined protocol, or recipe if you will, for data gathering and equations. It is the present feeling of this group that the third level would really involve the use of a specialist with 2 or 3-dimensional physical transport models, steady state and/or time variable and fairly sophisticated types of analyses that involve field data and validated calculations. So in summary that is where we are with that group.

Dom DiToro: We recommend that in Tier I the proposed material or some deposit sample thereof be subjected to a 129 Priority Pollutant GC/CMS Scan. You have to know what chemicals are there. We saw no way of arbitrarily picking the chemicals. So you spend your money and get yourself a Priority Pollutant Scan and a metal scan.

We also make a strong recommendation that these techniques have to be validated at Tier II. There is no reason to assume that the equations in the protocol work. We have a lot of reasons to assume that they may be just rough approximations. As a consequence, our strong recommendations are that these things have to be validated in some sensible way to make sure that they produce answers that are at least order-of-magnitude correct.

The final thing is that we strongly recommend that the analysis be commensurate with the magnitude of the project and the magnitude of the problem involved. Spending a nickel on a $10 million project to analyze this problem of fate seems to us (and I think I speak for the group) to be silly.

Vic Bierman: There is a lot of data sitting out there for existing sites. Most sites have a moderate amount of data. It would seem to make emminent good sense that once a tiered assessment methodology is constructed, that this methodology be tested as best we can against the existing data sets for a range of dump sites, for which there are data. The purpose is to address the issue of uncertainty. If you do not ever go out onto the field and gather data and attempt to field validate these calculations, there is no sensible way to put ranges of uncertainty on these numbers.

One of the points that was made by the policy group, and we discussed this in the exposure group, is that a manager cannot simply deal with a single number. He has to know that that number is in the middle of a range which has specified boundaries. The only way you can find this out is to have done a sufficient number of data intensive, site specific case studies where you attempt to validate the different tiers on these data sets. Then you can make a hierarchy of successive approximations at each site, and ask questions like: Does Tier III give you a good fit? What do you lose by going to Tier II? What more do you lose by Tier I? And what are the successive expansions on the ranges of uncertainty? Once you gain some operational experience by doing this, you can come back and tag these tiers with some uncertainty ranges.

4.3 Group III: Hazard Assessment (Effects Sub-Group)

Reporter: John H. Gentile

The more we got into this discussion the more difficult it became for us at Level I to really quantitatively link exposure with effects. Now let me qualify that. What you have been hearing Dominic talk about in the water is all well and good because we have got one monstrous toxicological data base in the water, and a variety of other data bases to work with. We went back and thought about the basic principles that already existed in the protocol in Section 7. We came up with three things. The first thing we wanted to do was describe what species and habitats were at risk. Those two items were already in the 11 factors that must be considered in Section 40 CFR. In addition to that we wanted to describe some level of community structure. Having done that, we now basically have identified what organisms are out there, somewhere, at the site. These exposure guys are going to give us a bunch plumes of various materials floating over the site. If you step out of the water quality types of calculations, you are left with suspended particulates or solids. It was my best judgement that we do not have a data base that allows us to connect effects with concentration gradients of suspended solids. We cannot connect those concentrations to biological effects in a way similar to what we can do with water. So essentially in Tier I, given this distribution of specific habitats if there are any resource populations and community structure, what is the exposure field going to look like? That way we get at the first question: do we have populations at risk? If they are at risk, depending on what concentrations look like from the exposure fields, maybe we can recommend moving the site. We had a lot of input from our own group in EPA and the Corps of Engineers in our working group. This would allow the site designations to make some adjustments in relocating the site. So what we are going to do in Level I is basically go through the front end of Section 7 of the Protocol, and beef it up. There is a lot of good information in how 301(h) approaches its problems. But that now is quantitatively uncoupled from the hazard assessment in Tier I. It is qualitatively coupled. Somebody asked the question, "So what are we gaining?" Who was the one who asked me? I guess what I answered to that was, "Before we had a lot of biological data, that really was uncoupled from any exposure information. At least now we know basically whether we have a potential exposure impact". How to quantitatively couple it becomes another issue.

I want to mention a point Rick Swartz made. There is a relationship that has been developed for suspended solids emissions from sewage sludge and trophic index for benthic communities. That is one type of quantitative relationship similar to water quality criteria (or if we have sediment criteria) that we could use in connecting the exposure field to those populations, but we really don't have that worked out. We felt that that's what we were talking about really in site designation. When we got to the next step, two other major blocks came out. If you go into the permit process itself, you are into a data gathering exercise. You are into a lot of biological testing. You now can start to couple the effects you see with concentrations, so you can start to make that quantitative link, at least in laboratory situations. You can also start to couple residue levels with effects responses, again in the laboratory. But if you have generated some of that laboratory data, and also if you can generate some field data, you then can start to develop a data base to make some of these kinds of connections we saw that happening in Tier II, and then Tier III. There was a strong desire to build monitoring efforts back into the program early on. But those monitoring efforts included doing sediment toxicity work and a variety of other things. So those are the three major blocks we had. To couple effects with exposure we felt we could not do it off the top except in the case of water. That would require research effort of another tier that we could identify. We could lay out the strategy for that. I might point out that it should not have surprised me that we came to this conclusion since we have a program going on right now that basically is designed to address those specific relationships. So that is where we ended up.

4.4 Group IV: Policy Issues
Reporter: Tudor T. Davies

Here is a set of principles in which we are not in agreement, and for which the terminology is under dispute. I think we are perhaps a little more practically oriented than some of the other groups because we were very concerned about the difference between the site designation process and the permitting process for specific wastes. We found difficulty in decoupling these two issues one from another, great difficulty. I think we returned to the same spot about three times after we thought we'd made progress. Our basic principles are the following. First of all, we have confidence that the technical groups will do an evaluation of the protocol. (We did have confidence up to this point). Individually the members of the group felt there were some technical deficiencies in certain areas and we thought that we could trust the rest of the group would sort those out and come up with a protocol that was scientifically defensible. That is the first non-principle. The thing that we did all agree on was that we felt that the protocol does not address the process for initial identification of candidate sites to minimize any impact and that this should be included, perhaps following the basic principles in that law. We did in fact develop a tiered system. Can somebody find amongst the flip charts the tier that showed initial development? This is of course preliminary like everything else. We printed it small so nobody could read it at this point, but you can see that we do have a tiered system. The first tier is the initial candidate site selection. The second then we consider to be the development of the site designation. The third tier we think is the very waste specific issues we have to look at to permit the dumping of the waste at a specific site. So our first principle was that step one needs to be elaborated upon. The second runs contrary to the one that was made here. We felt that we should not use a worst case example. Again, we are not in complete agreement on that. We felt that we should use our best judgement, or the person that was designating the site should use his best judgement on the probable waste and the loading of that waste that would be disposed of at that site. This should be the focus in the initial site designation conceptual development.

The philosophy embodied in the protocol of developing a quantitative assessment at a specific site is supported by the policy group as the reasonable approach to site designation. That was a big step. We felt that monitoring was very important. We spent a great deal of the time discussing this and we have very different interpretations of what I was trying to say. People who work at the lab know that that is really a problem. The principle is that the special or key limiting issues which are defined as being limiting in reaching a decision on site designation should be the key issues that are addressed in a monitoring program. We can discuss that at a later meeting.

The fifth is that validation is very important. I think we would support a site specific study to take and fully implement the protocol that we might come up with on a specific site, and that this would be very important in defining the range of uncertainty, the precision of estimates, etc.

The other thing that we felt was important is that in the initial site selection we select a point and that the protocol will be very useful for specific wastes in defining the boundaries of the site. We felt that was pertinent.

The other issue that we thought was significant was the following: if we develop a protocol, set of guidelines, whatever you want to call it, it is important that we decide whether we want this to become part of a guideline or eventually part of agency policy that will be imposed upon someone who wants to designate a site or perhaps later to request a special permit for disposing material.

4.5 General Discussion

Harris White: Groups 2 & 4 have at least mentioned and perhaps addressed in depth the question of uncertainty. Groups 1 & 3 have not, or I didn't hear that. I would be interested in a response to that. Secondly, I detected in the Strawman protocol as well as in the issues that were put on the draft program, an omission of degradation rates of contaminants, and I do not detect that in any of the presentations and I am wondering if that is being considered.

Vic Bierman: Tom, what about uncertainties in your group?

Tom O'Connor: In the context of the physical processes distributing the dumped material, the uncertainty comes in the data. Initially you have to make the best estimate of the current velocities and the wave regime. You need to acknowledge that you are not that certain, and if you want to be more certain it is not a matter of changing the calculations. It is a matter of going to the trouble of collecting more precise information. So our tiers are based on the level of effort associated with information acquisition.

Harris White: I think we are talking about different kinds of uncertainty. This protocol lays out a program of connecting in a quantitative way inputs of contaminants and impacts. We would like to make a statement about how certain those impacts are, and that would be a combination of a number of uncertainty terms. You need to provide that quantitative estimate of uncertainty.

Tom O'Connor: First of all, the physical processes that distribute contaminants are uncertain in the context of how well you know the numbers. In terms of your uncertainty about the biological consequences to that distribution, I think your first order problem is just which biological response you care about. Once that is done then you can decide how uncertain you are about implied body burdens or consequences of them, if those are the consequences you are concerned about.

Jack Gentile: If you want to talk about the uncertainty between linking residues with effects, I think you are talking orders of magnitude. I mean, we just don't have the data base. It is almost like raising an academic question, and we don't have data bases to link residues and effects and that is an endpoint that you are going to back calculate to where Tom is.

Tom O'Connor: In this tiering business, in the context of physical distribution, as you improve the quality of the data you use, you improve the accuracy of the calculations. Even in Tier I, where you have the least certain data, you can go through and distribute by the protocol a sensitivity analysis, how much things are going to change if in fact these parameters change. We are providing for that.

Vic Bierman: The element of your question related to degradation is implicit in the charge to the first group under chemical transformation. Transformation can be construed to mean transformation from one form to another through degradation. It seems to me the way things are developing with groups 1 & 2, that the chemical transformation and degradation issue probably more properly belongs in the exposure assessment sub-group. So why don't I just ask that group to make sure you consider that before you are through.

Dom DiToro: We did not consider that because, it is not applicable to heavy metals. The rate at which chemicals such as PCBs degrade is notably small. The rate at which chemicals degrade is unknown, by and large. So in order to be on the safe side, we decided to assume that everything is conservative. To get back to your first question of uncertainty, we made some statements about uncertainty. In point of fact, we are uncertain about how uncertain we are, because no one has ever tried these methods. These are idealized constructs of the real world. One doesn't know how uncertain these things are until he has tried them.

Bob Huggett: Tom, if your basic assumptions or equations of sediment movement assume that the particles act as individuals, they don't have cohesive sediments tied into this, and bed failure and sheer stress and so forth, how does getting a more significant number of current measurements help you decrease your error?

Tom O'Connor: It doesn't. In fact we did consider that. There is a point where it really doesn't matter how precise the velocity values are because you cannot get away from this and that is a fundamental weak point in the whole analysis. We put limits on how precise your estimates will be.

Mike Norton: I see some major problems emerging in the different ways the groups are going, both in the ways they have set their boundaries or not set their boundaries, and in the way that require some very precise data which another group is saying they cannot use. In the policy group, we did discuss (at probably too much length) how the site designation stage fitted in as opposed to the candidate site selection and the specific permit application stage. We decided that designation ideally had to fill in between those two extremes of a first shot and a detailed analysis, and that you shouldn't seek to duplicate everything that is done in the specific permit application. To that extent, we had to accept that we would be dealing with a generic type of waste. We would have to have a certain amount of information on the waste, but we wouldn't need 129 analyses. We wouldn't get that specific data, yet we do have 3 tiers. The third one is extremely complex and really, in my mind, fits very neatly into the site specific permit and possibly beyond the specific permit. So there is that problem, where in fact we should be going in the context of site designation. The other problem I have is that having generated all this data we have the biological group saying that everything is so imprecise that we really cannot use this degree of detail. So I see these problems, and we have got to have some boundaries in which we spend the rest of the week.

Rick Swartz: There are two aspects of exposure that can be pertinent to an assessment of biological effects. The first is just to document the spatial or temporal extension of the material into the environment so that you can see what assemblages are affected or touched by the material and you will know which ones you will have to consider as being in any way responsive to that impact. And therefore a lot of the fate and exposure work can be useful in the biological assessment. But the much more difficult relationship between exposure and biological effect is the nature of the dose-response relationship. In ocean dumping we deal almost always with complex waste mixtures in their initial release state or as they accumulate in the sediments. I believe that the present state of the art with respect to interactions between pollutants and their gross level of stress on biological systems is so woefully inadequate that it becomes impossible to implement the second kind of exposure-effect relationship and that is really the one we want to do. We have decided to largely abandon the protocol with respect to that second aspect of the effects prediction and delegate it to a part of the permitting process, where we know exactly what the contaminants are. Maybe you have a situation where one single contaminant is most likely to be the dominant factor in that stress. In such a case that kind of relationship might be established on the basis of predictions or empirical observations, but in general, in order to establish effects we have fallen back on many of the much maligned classical approaches to environmental monitoring. Our hope is that we can suggest techniques of using established questions like: Are there differences in space or time between biological assemblages? Can we correlate those changes? Or perhaps the biological perturbation. That is the approach I think will be emphasized in our group.

Vic Bierman: You seem to be suggesting that there is a good prognosis for implementing a hazard assessment methodology in which you quantitatively couple exposure and effects, but that the data requirements for doing so in terms of the waste characteristics, and to some extent the site characteristics, are sufficiently intensive that it is more properly part of the permit process rather than the site designation process. Is that what you are saying?

Rick Swartz: I think it is more than intensive, I think it may not be possible in many instances, and I suggest that it is most likely to occur when you do know the specific waste. Therefore, we put it in the permitting process as one approach, but only one of several predictive methodologies.

Dom DiToro: That puts our exposure group in something of a quandry. We had decided we were going to do this thing in some numerical way. We had no problem in looking at concentration fields and looking at biotic distributions and making an intelligent, at least an informed, judgement at Tier I as to whether they are close together or far apart. Beyond that, what you are telling us is you are not going to sign off on anything else but that. What I am wondering is why don't we follow, or have you thought about following the much maligned, but at least available, water quality criteria. You take a reference sediment contaminated with a specific chemical and measure the acute and chronic toxicity to a series of organisms. You generate that data base, which would then give us the specific criteria in clean sediments, in doing the site selection.

Rick Swartz: That is an area of research, but I think it is a bit premature to make it a central part of an applied regulatory decision making program.

Dom DiToro: But can you come up with orders of magnitude or something?

Jack Gentile: We are basically working with complex materials in the sediment. There is just not that kind of data base. I mean you can come within a couple of orders of magnitude, if that is all you are asking.

Dom DiToro: I am not asking you to do complex materials. What I am asking you to do is single chemicals in clean sediments and clean organisms, just like water quality criteria are done with lab water and copper sulfate.

Jack Gentile: Can we develop a data base from this point of view?

Dom DiToro: Yes, would you consider that these experiments would provide an analog of the water quality criteria in the water column, much maligned lately, but never the less numbers that can be used for these purposes.

Jack Gentile: It is one approach that we could use, but we just did not feel at this point that we can do that. That's a development piece of work. There is a problem with developing it that way too. The state of the art isn't there in sediments.

Harris White: I fully support what Rick is saying and I assume he is speaking for the concensus of his group. I don't see that it is incompatible with what we are doing here. I suggest that we consider a tiered approach in the sense that the first tier is a site identification that would grossly look at resources at risk. The second tier would take us through the physical and chemical processes, the exposure, and that would be the basis for designation. Tier III would get into the site specific sorts of things that Rick is talking about where you need to begin looking at interactions and synergisms. That would come in the permit process. Perhaps the tiers could be arranged on that basis.

Vic Bierman: Identify, characterize, designate, then permit is what you are saying?

Harris White: Yes, with the designation ending at the exposure point, not at effects.

Bob Pierce: I think that one of the fundamental things that should be recognized between the effects group and the exposure group was that we adopted the policy that the policy group ultimately came out with and that is to try and develop something that we had thought was realistic and best judgement as opposed to worst case. And I think that is where we are coming from, looking at what we can do now or what we do know now, and not trying to project a worst case scenario.

Percy Donaghay: We ran around in a circle for about a half a day talking about the candidate site selection process. The only solution that we were able to come up with was to say, "Can we turn the whole process around and look at the problem from the point of view of how large an area will be impacted by amount of material, given site physics and so forth." Can we get ourselves out of dealing with problems that really aren't problems, like taking clean sand and dumping from one place to another. If a substance got through that first filter then there was basically zero risk. If it was not able to pass, then you head for potential problems and the old question that Harris White has raised about uncertainty becomes a central issue of the problem. You have to estimate risk as part of the whole protocol that you want to do. Our sort of best judgement approach has resulted historically in terrible mistakes. That is usually, "Well my best judgement was it wasn't going to be a problem." I think this whole exercise is an attempt to get us away from best judgement and toward actually making some quantitative analyses of the uncertainty involved. So I think that the first step is to say, "Okay the worst case is that we have a problem." If the answer is potentially or maybe that we have a problem, then we have to build something from there. So I think we really need that first worst case and then to go from there. But I really get nervous when we start talking about best judgement as a sort of rule of thumb. I think we have a terrible time doing that.

Vic Bierman: I think where Percy was going was trying to introduce the analogy that the group made with a waste load allocation problem setting for surface fresh waters, where you work backwards from specific criteria. Dominic, could you elaborate please?

Dom DiToro: The way the calculation for surface water is done is as follows. It is done essentially backwards, since the equations are all linear. You take the unit loading of materials: 1 kilogram per day of, say, cadmium for example, and you calculate the fractional concentration that you would get by diluting it into the receiving waters, step 1, by diluting it into the sediment receiving volume, step 2, and by fluxing it out into the overlying waters. Then what you do is you go backwards, and you apply the criteria to those concentrations and back calculate what the acceptable loading of each material is. That site then, as an upperbound, could receive that loading. If that loading is larger than the projected loading for the wastes being designated, you are home free.

You have got to decide the worst case for any specific material. We ran a couple of numbers through the calculations and it does not appear that every site fails that calculation. It is not true that every waste and every location fails. It gives you a comparative way of looking at the various characteristics of sites. The second tier can also be done that way. It is again conventional in certain types of water quality analysis to back calculate the specific loadings. So in a sense, you do not have to have the waste characterized. What you get out of the calculation is the amount of material to be discharged at that site, of that chemical without violating the criteria there. So we neatly skirted around the issue of having to quantify in detail what the waste had in it. If you have a potential problem at Tier I, then you go the second level and do a better job.

Norm Rubinstein: You cannot reject the materials, you can only accept them. In effect, as you go further along in the tier process you are in fact accomplishing what used to be the permit evaluation. You have generated a large enough data base to make that permitting essential.

Tom O'Connor: What do you use for the flushing rate?

Dom DiToro: Well that is a little bit complicated. The initial dilution and acute toxicity computation is fairly straight forward. The hardest question that we face was: what is the sediment volume into which you dilute an annual load of contaminanted materials. We said a good estimate a mixing depth on an annual basis is 1 cm. That comes from 0.10 of a cm being too small and 10 cm being too large. That number gets refined by the calculations that are in the protocol. But to order of magnitude it is the correct depth. Now then, what is the correct area? Well, you do not ask that question. What you do is estimate the load and you then take the sediment criteria and compute the surface area of the volume at that concentration. That is the maximal impact area that could happen at that site. If the area were larger than that, organisms would be below the effects levels and nothing would happen. If the area were smaller than that area the organisms would be exposed at higher levels than the effects levels but there would be fewer of them. Therefore, that is the maximal impact area.

Percy Donaghay: One of the thoughts which some people kept bringing up was by definition anything that falls in a site is irrelevant as long as it stays inside that site. In other words, the site has been written off. So what we are trying to calculate is the amount of impact that is going to occur outside of the site itself. The equations or the system that Dominic has been going through basically allow you to get an estimate of that. If everything stays inside the site, you do not have a problem. What you are worried about is those in-between cases. That is the whole objective of this sort of exercise: to see if we could get a solution without having to go through the effects people. In other words, can we get some solutions now before we have a sediment quality standard? People are going to make these decisions. And yes, we absolutely need these standards. But between now and the time we get those standards can we make a few decisions and have some chance of being right.

Bob Huggett: Given that these sites have to be designated very quickly. Do you have the chemical criteria to calculate your errors?

Dom DiToro: The water quality is no problem. The sediment criteria are another story.

Bob Huggett: Water quality is no problem? How about some organics? Give me some organics.

Dom DiToro: There are criteria for the major pesticides, the toxic heavy metals, about 15 organics, 8 or 9 heavy metals. Look at the table in the proposed protocol.

Bob Huggett: There is supposedly clean material designated to be dumped off the coast of Virginia. We have documented 316 organic chemicals. Now I don't know what they do individually much less together, and I don't know how you are going to make your calculations based on existing water quality criteria or sediment criteria.

Dom DiToro: Well, Bob, the water quality criteria are upper bounds of safety.

Bob Huggett: I don't have any problem with what they are. I have a problem with the limited number of them that you've got.

Dom DiToro: Without water quality criteria for specific chemicals there is no way to apply water quality criteria to specific chemicals. At that point, you basically fall back on bioassay techniques. Namely you make your argument that if the organisms develop some sort of neoplasm you really don't want to discharge with this material. We took a position that is already in the regulations. Whether you agree or not, the process that you go through is irrelevant. That is the way the assessment is done. We are not saying that you do not do toxicity testing to supplement individual chemicals, but that you look at the principal chemicals individually so that you can see what is going on in a more specific way.

Tom Wright: Let me just follow up on what Dominic said. Basically even right now under the existing procedures you can not rule out the presence of all these wonderful things. How many are there. . . 316?. . . . that may occur and do occur. You are forced back into what we face right now, which is to run bioassays etc.

Dom DiToro: Just to contradict a little, the problem with the current regulations, as I think everyone understands, is that the level of protection that they provide for is unknown. At least if we take the next step, relating loading rates to exposure concentrations to effects, you have the possibility of analyzing what your level of protection is. The current regulations do not claim to quantify what that protection level is. What they say is that if you do this, it is their best judgement that the action will be "safe".

Bob Pierce: I hope people are understanding that even when Jack Gentile earlier said that we couldn't do the exposure-effect linkage right now, we cannot even do exposure-uptake linkages right now, let alone the meaning of uptake with respect to effect. We cannot take the sediment and predict how much an organism is going to find available and take up let alone go the next step and say once it has taken up that amount what effect is it going to have on the organism. So we are not strictly at the point of not knowing exposure and effect. We are another magnitude below that.

Doug Segar: You have got less than 20 or 30 parameters in the back of the proposed protocol which are listed as EPA marine quality criteria and there are a lot of words still around but I think it is important to make it clear to everyone here just how many of those parameters and which parameters are actually quality criteria as of now and which are not. The majority of that list are not in fact legal criteria as of this time.

Jack Gentile: Criteria have no legal standing until they are translated into standards. Criteria by themselves have no legal basis. So you ought to get that point clear. They are recommendations. It is only when they are translated into standards that they become law. So what we are saying is that, for those compounds' dissolved total phase, the criteria are the best compilation of toxicological bioaccumulation data you have at your disposal, your best estimate of effects for that group of compounds and a bunch of others.

Doug Segar: Okay, then how many of those have formally been adopted by the EPA?

Jack Gentile: Basically, all those listed have been satisfied essentially to the letter of the consent decree. Translating those into state standards is another issue that has not been done, but in fact they can still be used as the basis for making regulatory decisions, and they are every day.

Norm Rubinstein: In response to Bob Pierce's comment about our inability to predict body burdens, we don't actually predict them. We actually go ahead and empirically measure bioaccumulation. It is not really predicting though. It is a fairly good hard data point that we go out and empirically produce.

Bob Pierce: I wasn't arguing that, Norm, in the mode where we are going into a bioassay routine in doing it. What I am saying is to get to the level that Dominic wants and just to be able to take a sediment and predict how much is going to be taken up, we can't do that off the top of our heads.

Norm Rubinstein: We cannot predict what's going to be biologically available.

Bob Pierce: I am saying so. It is not a matter of exposure concentration and effect, it is exposure concentration not predicting availability, and then once you find out what is available not knowing the effect beyond that because once an organism has taken it up that says nothing about effect. Unless it can cause some effect, there is no real reason to be concerned about it being in the organism.

Dom DiToro: That's true. No one has a reasonable way of estimating the bioconcentration factor. However, it is known based on the information of the members of the group that the bioconcentration factors from sediments to organisms have not been observed to be greater than a factor of 10. Therefore in our upper bounding calculation we suggest you use a BC factor of 10, knowing that that number is higher than any known case. Since our mode is upper bounding we use the highest number that seemed feasible.

Bob Pierce: In New York harbor, if we assume 10, we would say that everything fails FDA standards for PCBs.

Dom DiToro: No, what we would say is that you have failed Level I screening. Therefore, better go to Level II. It is not surprising that the New York harbor fails screening methodology that is designed to eliminate the non-problems. It should not be surprising that that happens. We designed level one precisely to screen problems from non-problems.

Bob Pierce: Yes, but on the other hand there are no organisms in the New York Bight that have been identified that exceed FDA standards.

Dom DiToro: Whether true or not, there is a very large shellfish closure region there for some reason. You understand the motive on which we operated?

Bob Pierce: Oh, I understand it. I don't accept it, but I understand it.

Harris White: In view of the hour I would just like to get some agreement so that we can proceed tomorrow. I think one bone of contention is whether we are working with upper bound worst cases, or whether we're working with representative or typical average. I think that needs to be agreed on for our work tomorrow. I know it does for our group.

Vic Bierman: It would be nice to have agreement on whether we should go with upper bounds or whether we should go with best scientific judgement. I think that now that the issue has been laid out on the table, the individual groups are just going to have to go back and work it out. As Dominic mentioned, in the case of waste load allocation for streams, the standard practice has been that you do a worst case calculation because that's the basis for the conceptual approach for doing that kind of thing. So I guess my first response would be we're already doing it in fresh water, why not do it as at least one of the approaches here. Call it Tier I, call it Tier II, call it Tier 1A. But since we're already doing it why not at least transfer the experience and the conceptual framework to the ocean recognizing that if we go to Tier I or Tier II or Tier III and you're purporting to do something more accurate and more realistic, that moves you away from the worst case boundary. Now you're somewhere in between worst case and knowing exactly what happens. Then it would seem it's encumbent on you to define ranges of uncertainty about that single value. I don't really see how we can avoid doing both sets of calculations. It really depends on the level of resolution and data you have to support the calculation. So I guess the bottom line is I would say that there is room for both approaches. I don't think we ought to restrict ourselves to just one.

Bob Pierce: I would ask Tudor Davies. You did make a statement on this exact subject in the policy group. Was that a concensus of the policy group? Would you go with best judgement as opposed to worst case?

Tudor Davies: No, I don't think it was. Frankly though, I am not sure whether I would agree on going with a worst case example in site designations.

Vic Bierman: Okay, that's a policy issue I think your group has to make a recommendation on. But I think it doesn't really affect the technical groups that much, if the technical groups have already decided that these are the methodologies that we're going to recommend as a part of a hazard assessment approach. Now if a definitive policy recommendation comes out of your group, then when we go to synthesize these recommendations with the present version of the protocol, we simply will eliminate one or the other.

Tudor Davies: I think what I'd like to have is a very specific defense on the worst case step in Tier I in the site designation step.

Vic Bierman: The technical groups are addressing the issue of developing a predictive assessment approach for assessing the impact of dumping a waste at a site. I think if the technical groups concern themselves with what site designation is and what permitting is we're not going to get a thing done. We'll develop the technical methodology, and we're looking to the policy group for direction as to what the application of that methodology is to be in the context of the site designation decision versus the permit decision.

Tudor Davies: We are talking in terms of tiers, and I think there should be some consistency. For instance, for the site designation step before we get into a very specific analysis of waste, that should correspond at least conceptually to the tiering that the other groups establish.

Doug Lipka: I think it does, Tudor. If we consider the site designation process as not having any tiers, and we accept what the effects group has given us, and the exposure group doesn't use worst case conditions but use a probable or average condition in the site designation process, and in the permit process we would utilize the tier concept with worst case conditions and bioassay testing so that you can get through your acceptance levels.

Tudor Davies: I've been thinking of what corresponds to our designation tier as being only exposure.

Doug Lipka: Exposure, and as far as effects, what was recommended at level one, which is just a description of the community and natural history.

Tudor Davies: Tier I

Doug Lipka: Which is now our Tier II. I think we have two different sets of Tiers which are compatible. Tiers in the sense of the process, but the Tiers they're talking about are in specific testing. Ours are not.

Vic Bierman: I don't think we could map the policy tiers onto the hazard assessment tiers. However, if you can define for us in terms of policy guidance the level of intensity, the level of data, the intensity of the data gathering effort that you will recommend for site identification, site characterization, and the permit process, then it's a straight forward matter for us to develop assessment tiers, exposure and effects, compatible with the policy tiers. But it is better to do it the other way. Let's select our tiers technically and we'll tell you the level of resolution of our methodologies, and you've got to make a policy decision as to which tier you want to use from the hazard assessment for each of your policy tiers. But right now I don't see a tight coupling.

Tom O'Connor: You know, dredged material has to be put somewhere, and we need an assessment of where's the best place: upland, confinement areas, in the ocean, whatever. If everyone concerned with each of those individual media were to make a worst case analysis, it wouldn't be acceptable in any of those places.

Vic Bierman: Are you suggesting we should go solely with best judgement and not with worst case?

Tom O'Connor: Yes.

Tom Wright: You probably think I'm losing my mind because I haven't said anything about the distinction between designation and permitting today. But we've decided in our little group right off the bat several ground rules: (1). We're not going to worry about that; (2). We're not going to pay any attention to the established regulations, policies, protocol or what have you; (3). We are not concerned with practical implementation or anything else. These are all issues for the policy group. Dominic, don't you agree? Those are the ground rules that we operated upon. If we don't have the technical approach all operating on the same ground rules we're not going to be coming together. Here are the ground rules. Don't worry about designation and permitting distinctions. Don't worry about the regulations or the practicality of implementation. Come up with what we ought to do.

Vic Bierman: Tom, I support your remarks. I've said that individually to each of the three technical groups. I said it in the policy group and I'll say it here. We're addressing the issue of the impact of the waste on the site and we've got to look at the difficulty we've had in trying to relate the exposure field with the effects. We haven't resolved that technical issue yet. And I think until we make every effort to do so, we ought not to worry about compatibility between the technical tiers and the policy tiers.

Chris Shilling: There's a couple of points we keep going back to. We keep talking in terms of what's happening inside the site and somebody mentioned this probability. Inside the site you're assessing the damage. Regardless of what it is, you're assessing the damage. But somethings I haven't heard you mention I'm not so far along that I'm worried so much about some toxic thing. I'm worried about whether the stuff hits somebody on the head and kills them. Now what I'm talking about is that you have not said to me how much of this material should be on the bottom.

Dom DiToro: That's true. We did not look at suffocation as an endpoint because frankly it never occured to us. It would seem to me that one could calculate rather easily the thickness of material and the area over which that thickness would extend. I think that's a valid calculation.

Norm Rubinstein: We did bring out the fact that the immediate impacts on the benthos would be a write-off. Not outside the site. We were talking about a layer of approximately a centimeter in thickness.

Dom DiToro: We're talking about a mixing depth of a centimeter. Chris is saying, "What happens if this material diffuses, spreads over an area, and generates a thickness which smothers all of the organisms in that area. What is that thickness and what is that area?" I have no idea what the thickness of smothering is. It depends I'm sure on the organism and their ability to suffer boulders and that sort of stuff. I don't know. I think maybe we should consider it tomorrow morning and come up with something sensible.

Let me try and get at least one pitch in. I am the last person in the world who likes worst case analyses. Let me tell you that all of surface water quality analysis, and I mean all of it, is governed by essentially very improbable cases. One takes a very low stream flow which has a 10-year return period. Into that stream flow you put the average loading coming from your point source. That number has a fairly low probability of occurring, because high loads dominate arithmetic averages. Calculate a concentration and compare that with water quality criteria which are very safe criteria. You've then spent millions of dollars building a treatment plant to meet that calculation. Now, you tell me that it is irrational to do worst case analyses in dredged material, and I tell you that it is irrational for EPA to regulate surface water quality in streams estuaries and lakes using those sorts of rules. I am perfectly willing to agree that that is irrational. What I'm saying is there is a precedent which has stood up for 20 years for doing the allocation procedure in exactly that way. So if the worst case analysis applies to streams and estuaries in terms of construction design loads, then why is it not reasonable for Tier 1, the simplest analysis of a similar sort for a dredged spoil.

Tom O'Connor: I think there is a difference between worst case and extreme case. Extreme cases really happen.

Dom DiToro: Then take 10% less of each of the numbers that are used in the worst case analysis, call it an extreme case, and there you are. What we are hoping is that if that is the point where Level I failed you immediately make more realistic judgements. You use some data which presumably you beg, borrow, or steal. On the other hand, how does one make a best judgement about biologically available copper in dredge spoil.

Chris Shilling: Will you interpret for me what you mean by a worst case?

Dom DiToro: There are three analyses you run in the worst case. I'll take the last one first. On an annual average time scale, if all of the material that you have discharged in a year were released into the water column nothing will accumulate in the sediment. So if you have some number of kilograms per day being deposited on a yearly basis, you assume that all of that material is fluxed out of the sediment. Nothing could be worse than that. Now if you want an extreme case you assume 90%. A more useful number might be 50%. The point is that, in the absence of real data, some fraction will be returned in the water column. You then go through the protocol calculations to give you flows, lateral dispersion coefficients and you calculate the concentration fields. Those fields will be mapped against the biological community and you decide one way or the other whether you have a problem. That is one of our worst case calculations.

Chris Shilling: Then you are not talking about a worst case in assuming that the dredged material or sewage sludge or whatever is the worst of the worst.

Dom DiToro: No, that's a good point. We're using a realistic composition of materials. We're not using the worst dredged spoil material anyone has ever found. If any of you have come to that misconception, I'm sorry.

Percy Donaghay: One of the things we did that we recommended in this process is that we always use the physical calculations that are in the protocol or whatever modifications there would be, but we recommend strongly that a sensitivity analysis be done. Increase the physical transport by a factor of 5 or whatever, or decrease it by a factor of 5, and see whether that runs into the boundary conditions. But we don't ever deal with a zero transport consideration for an environment which is known to be so turbulent.

Doug Segar: I think the problem is a semantic one. The worst case conjures up a very different picture in most people's minds than you have in yours, particularly since we've got something in this document that we have been given to examine in this workshop. I think we really ought to avoid the term worst case. It's just too emotional.

Dom DiToro: I think maximal exposure is a nice, effective word.

Vic Bierman: In analogy to the total maximum daily load which you would end up with in a stream calculation?

Dom DiToro: It is very analagous to the way stream water quality analyses are done.

Jack Gentile: I just love Dominic's engineering approach. It just blows my mind. I just was thinking here that we could make some assumptions similar to the type you're making, looking at the benthic communities, which is where we were hung up. If we were to assume that for the most part uptake and toxicological effects were mitigated through the aqueous route, and we were to assume that pore waters were in equilibrium, and everything was equal, then the benthos would be essentially exposed to an aqueous media. So we could use exactly the same kind of calculation. I mean we could just take your concentration gradients, basically still use criteria data bases to come up with a similar kind of phenomenon for looking at these organisms living in the sediment. If you're willing scientifically to make that kind of jump which it sounds like there is a basis for doing, as long as you know the limitations on it and the assumptions inherent in it.

Dom DiToro: Yes. One should really develop a little courage when one is out in the woods. Approximate engineering calculations are a way of life to practicing folks who have to deal with real problems. One is not saying that this is how the world behaves. One is saying that if nature conspires to be utterly malevolent, this is the worst that could happen. But at least you're clear about what you're doing. It seems to me that the toxicological community could come up with something reasonable, to within an order of magnitude to guide the Level I selection. Frankly, gentlemen, comparing organism maps to concentration diagram strikes me as being a little bit crude for the 20 or 30 years that aquatic toxicology has been in business. If you can't do anything better than that on an order of magnitude basis, then try.

Tom O'Connor: If I were to take that same approach in considering an upland site for the disposal of dredged material, would it be equally legitimate and equally correct to assume that everything that I dump upland would immediately end up into groundwater? Is that the corresponding assumption?

Dom DiToro: No, the corresponding assumption would be that the loading rate applied to the ground water would be the rainfall leaching through the contaminated material. You would set that rate at a reasonable upper bound. But not everything all at once. You can't exceed solubility.

Tom O'Connor: So we have some limits now?

Dom DiToro: Of course we do. None of these calculations are done in the dark. If you need to or want to be "scientific" or more empirical then I would suggest the following. You make an investigation of the literature since the availability seems to be the thing that's most puzzling to everyone. You make an inventory of the literature and generate the percentages of the material that appear to be available based on whatever kind of definition of availability you want, and take a reasonable percentage. If that is the only quibble we're talking about I would support any effort to come up with a reasonable estimate of the available fraction. I think that is probably an exercise worth doing. But at this stage, we didn't have that information so we either recommend doing nothing or, at the other extreme, doing complicated analyses which we know now to do....It's much easier to do complicated calculations than it is to do clever simple ones. Much easier. We're in the business of doing complicated water quality calculations. That wasn't our charge at this meeting as near as I can tell.

Mike Norton: Dominic, with his engineering eloquence, actually gets the biologists out of their laboratory, and almost gets them to generate some figures. But what we've got is really just nonsense cubed. He starts out with some sort of concept of availability and how much is going to be eluted out. Well, that's only the start of the problem. So you've got this material which has come down, and swamped and killed all the benthic organisms there, there aren't any there to accumulate metals in any case. You've then got the transport into water. You've then got to presume the tidal system, where you've got dilution profiles from the sediment-water into the water. There you are talking about uptake with free-swimming organisms because you've killed off the benthos. And by the time anything living is exposed to this it is going to have been diluted lots of times. So we're not talking about whether it is all just going to be leached out, whether it's going to 90% or 50%, we're talking about an order of magnitude here and an order of magnitude there and an order of magnitude somewhere else. I really wonder where we're trying to go.

Dom DiToro: Michael, I think you misinterpreted the Level I calculations somewhat. We do not expose all of the organisms to undiluted sediment dredged material. We do not do that. We diluted it into the tidal flow and disperse it by the longitudinal advection, and by the lateral dispersion coefficient, as per the protocol. What we are trying to do is upperbound the hard parts of the problem. The hard parts of the problem are how much material leaches from a given area of deposited dredged sediments. If you think that maximal exposure calculations are so conservative as to be misleading then I think that is a position you could try to defend, but it is the position which inevitably puts you into a calculational mode. The analog is not of buying a radio, plugging it in, and getting beautiful music out of it. Doing those calculations is not a canned routine that can be run on a microprocessor by someone who doesn't have a feel for the problem. This kind of calculation is much more like buying a violin, and finding yourself a violin teacher, and after three or four years, after you have a sense for the way music sounds and your ability to make music. You do these calculation and defend them. What we were trying to do is provide you with a rather tinny radio. If you don't want the radio fine. Just respond to the problem setting. If you think that those maximal exposure routes are foolish, I ask you to reflect on the methods that are applied to surface water.

Mike Norton: I'm not advocating that Dominic should try to generate a model of the complexity that I described. I don't think these things are really calculable in any meaningful sense. I would suggest that we look at a lot of other research work which has been done on dredged material sites, if we're just talking about dredged material sites, which have essentially tackled the problem from the other way. We are given a spoil which has so much contamination. Let's analyze the organisms we can find in and around that spoil and see how much they've picked up. There's a tremendous amount of data there, and it does not lead you to conclude that the pathway from spoil to bioassay is very efficient. It leads you to conclude that it's extremely inefficient. It may lead you to conclude that in the initial site designation evaluation, this matter is not the key matter that you should be considering. That's really what we thought you are trying to do at the site designation stage was rough out the picture, not get the last detail.

Bob Pierce: I'd like to pick up on this point. I think that we've ended up in the effects group saying let's not tier. In essence what we did and what Jack presented as our first level, we did relate his policy, as Tudor was suggesting earlier, to designation. There seemed to be a tie that this was the level of effort we felt was needed for designation. When we got more sophisticated than these very crude parameters, that we should go out and do better after twenty years. We were saying that that belonged at a different level than designation. So we did in our group at least I think tier somewhat on designation, than monitoring, and the regulatory approach, evaluating the actual waste. We would hold that some of the more sophisticated manipulations would belong beyond designation.

Chris Shilling: Dominic you specifically talk about maximal exposure, are you talking about bulk analysis of the bulk sediment, and all that is going to be leached out?

Dom DiToro: That is a maximal exposure.

Chris Schilling: Then you're talking about that whole particle disintigrating?

Dom DiToro: That's correct. That is the maximal exposure. Now if you would like to use an elutriate test result to modify that, you could certainly put in your best judgement. The problem is that that is not a maximal exposure, that is someone's "guesstimate." At least we're sure what we're doing when we do maximal exposure. That is a firm and defensible calculation in any case. A best judgement is a soft and indefensible calculation. That was the reason we went to maximal exposure. Before I came here, I spent a reasonable amount of time looking at some of the literature and there is a fair amount of information. The problem is that it is not codified in any sensible way. It is not codified in a way that people who do calculations on a routine basis can use. If you think that all ought to be codified, fine.

Rick Swartz: It seems to me that the elutriate test provides a more reasonable maximum exposure estimate. It is somewhat less misinterpretable and more consistant with the historic analyses of sediment proposed for ocean dumping.

Dom DiToro: Let me respond directly to that. The elutriate test for most metals shows that release is negative. That is to say that the metals are sorbed in the elutriate test. The conclusion from that, and I ask you to read the elutriate test documents, is that most materials with the exception of ammonia and manganese decrease in the test. The conclusion of the test is that the sediments would be a net sink of metals from the overlying water by diffusion. I defy you to support that in any sensible way.

Rick Swartz: I think it is a relevant observation.

Dom DiToro: But it is a wrong observation. Measured fluxes of materials out of sediments are positive upward, not negative downward.

Bob Pierce: Most of the literature supports that the sediments are an ultimate sink.

Percy Donoghay: There have been studies where people have made measurements of metals in the field, and in flow-through systems with contaminated sediments. Some of the metals do go in as predicted, but some of the metals which are highly toxic like copper come boiling out and maintain high concentrations in the water for very long periods of time. That's not predicted by the elutriate test. Part of the problem is that the biota and the bacterial processes which do not occur in the test have a very significant potential role for controling the flux of metals out of the sediments.

Bob Pierce: I wasn't pushing the test. I was just saying that in marine systems I think the literature supports that it was a net sink.

Dom DiToro: The way we set it up was that the mass loading in on an average annual basis, is the mass loading out. One final comment on diffusion out of sediments versus diffusion into sediments. It is inevitably the case that the concentration of metals in interstitial waters is higher than the concentration of metals in overlying waters. Either we've got something here which is a second law (of thermodynamics) engine, namely it drives against gradients, or the flux of dissolved materials is out of the sediments. Don't you see why we went to maximal exposure?

Percy Donoghay: One of the things we recommended as the absolute first thing to do in terms of going to Tier II is better than the elutriate test. Introduction of a partition coefficient is the biggest way to drop that estimate of risk to the environment. The reduction is probably going to be 3 to 4 orders of magnitude, and that's the first thing you do. Now we could shove that back into Tier I. We saw that as the primary step to try to make some more controlled estimate, because that's where the big difference is.

Mark Reed: It seems to me that the majority of the people in the room are paralyzed by the fact that we're dealing with a complex world. We daily find ways of making decisions in the face of great uncertainty. I think what's needed here, if you go back to the purpose of the workshop, is to simplify this complex situation, and perhaps bound the uncertainty. I agree that the uncertainty is of concern. What Dominic is suggesting is that we can estimate upper and lower bounds, and I think by all means we should do that. I do not think that simply because it's very complex we should all say, "We can't do anything about it. Let's go back to what we were doing before." I think that's avoiding the problem. There is a great deal of accumulated knowledge in this room. I think it's our responsibility to use what we know, perhaps not exactly as it is written in the protocol, but in some way that is useful in terms of the purpose of the workshop.

Vic Bierman: I would like to make some general comments along those lines. This really isn't a research exercise. This is an exercise to systematize and to assess the state of the art for considering exposure, effects, and whatever. We're talking about the 1977 Implementation Manual that EPA and the Corps of Engineers put out and so on, and we're saying, "Listen, the state of the art has advanced since then." I think one of the reasons we're here is to address what we didn't know then. Let's identify it, systematize it, organize it and develop some kind of a framework for gathering information and organizing information. I think that we shouldn't be afraid of taking a step foward in the state of the art because in 6 years, in 1989, we could very well be sitting here saying, "Back in 1983, we really didn't know as much as we know now. We've incremented six years and we could do something better." There are two parallel tracks. There's a research track and an applications track. Frequently people travel down these tracks totally independently. Occasionally there are certain junctures, certain points in time when an information transfer occurs, and we take the incremental information that we've managed to gain on a research track and we interact and we advance the state of the application art. So there's another increment there. What happens in the intervening five years or ten years the research continues and makes advances. The state of the art continues at a given level gains operational experiences, and then we have this juncture again. I think we're at one of these junctures. I don't think we ought to worry about doing things absolutely correctly. We shouldn't be worried about doing things right and finally and for the last time. We shouldn't worry about doing something today that might be improved upon five years from now. We're here to develop a systematic process for gathering information, organizing that information, and interpreting that information.

I think that the hour is getting late. I didn't have a specific cut-off time, if there are some more questions. Let me try to make some general points very briefly. There seems to be support for a tiered assessment methodology to address the technical issue of the impact of a specific waste being dumped at a specific site. I'm not sure, why the policy group didn't like the word "hazard", I'm not sure it's important at this point. I think we're obligated to consider maximum exposure cases, and I think we're obligated to consider best judgement cases. I think we're also obligated to offer estimates of uncertainty for the best judgement cases, and an estimate if possible of how far down the lower bound might be from the maximum exposure level.

Field validation of the protocol. Let's suppose that we develop this protocol along the lines that we're traveling right now, and we're talking about the exposure tiers and the effects tiers. I would hate to be in a position where I'm faced with either a site designation decision or a a permit decision, where I'm forced to use the first couple of tiers, and then go into court and defend this without the calculations having been field validated, having a measure of scientific validity, having been published in the peer-reviewed scientific literature, especially having to defend the ranges of uncertainty and so on. I don't think we can do that. I think the critical step, and the recommendation has come out of two groups, the policy group and the exposure group and I suspect that Jack's group would support this and so would Tom's, that whatever protocol that we come up with, we need to use existing data and we need to conduct field validations at one or more sites so that we can apply the common sense test. Do these methodolgies make sense? Are they useful? Do they agree with what we already know?

Regarding Tiers, I would charge the technical groups with being very careful to specifically define the data requirements for implementing each of your tiers. The physical, chemical, and biological information that you need on the site, the physical, chemical, and biological information that you need on the waste, and any follow-up monitoring requirements that might be needed for validation, if the recommendation is followed to test implement the protocol. Of course you can't implement it if you don't know what information you need to implement it. But the policy people need to know what level of intensity, what level of data gathering, what level of resources are required to implement an assessment protocol in a certain level. Then and only then, I think can they make some definitive policy recommendations as to what level of assessment to implement for site designation, what level of assessment to implement for permit decision, and so forth. I think it's incumbent upon the technical groups to specify in very explicit fashion the information requirements.

Tom Wright: Last week when we met with Pat Tobin, we raised two questions. One question was whether this workshop dealt with designation or with permitting. We were told that it dealt with designation. Now that's fine. Secondly, we pointed out that within the proposed protocol there was an awful lot that dealt with permitting. We sort of argued about that. We were essentially told not to deal with permitting and that that issue would be referred to the committee. I guess at some point in the future, we need to go back to the same COE/EPA committee that developed the implementation method. Now you have just said that one of our tasks is to revise the implementation method. Should that not be a joint COE/EPA effort rather than an effort of this group?

Vic Bierman: That's a policy issue that I'm not prepared to speak to. Pat Tobin has to speak to that. Let me give you the most honest answer I can, Tom, with regard to designation and permitting. I'm aware that that's a sensitive issue. I've been trying to determine in my own mind what site designation is, what permitting is, and where the boundaries are. I've had extensive discussions with Pat, his staff, and so on, and I confess to you that I'm not at all clear what the boundary is between designation and permitting. However, I'm clear on this. After extensive discussions and meetings and so on with the fellows who are actually designating the sites, the in-house task group, the technical issue, and that's something I can deal with, the technical issue is well specified. I've said this individually to the task groups and I'll say it here. The designation decision itself leads to a generic label on the site in terms of dredged materials, sewage, sludge, fly ash and so on. However, the operational procedure that's being used by the in-house task force and EPA, right now, is the following. The ultimate designation is generic but the technical issue is matching the characteristics of a known waste or wastes to the characteristics of a specific site. The reason is the site designation issue never arises unless you have a waste that you're considering for ocean disposal. Therefore, you always know the waste. So it seems that the only clear way to proceed in a technical sense, and the only clear technical charge that I can give is to say listen, "The immediate technical issue is the following: What's the impact of dumping this waste on this site." Let's develop an assessment methodology now. Your question is a policy issue to be decided by Pat Tobin, perhaps Tudor Davies, or the Office of Water. That's beyond the scope of this workshop, and it's an issue that I can't address as a technical coordinator. Here is a tiered assessment methodology. In my opinion, this methodology can be used. If you agree that the site designation effort is less intensive, there's less of an assessment. Perhaps, Tom, you would contend that there shouldn't be any assessment or level of protection built in at the designation stage, and we should handle that at the permitting stage. That may be one point of view. Maybe others have different points of view. Personally, it makes sense to me for there to be some level of assessment built in at the designation decision stage. But that point aside, I would say to the policy makers, "Listen, here is a hazard assessment protocol that will allow you to address the technical issue of waste on site." Now you make the policy decision. You can take this protocol and implement it at Level I in the designation phase. You can give this to Chris Shilling and his fellows and say, "Look, implement it at Level I. If you get into a tough case, you might want to go to Level II." We can say to the Corps of Engineers, or someone within the Office of Water can say to the people who write permits, or the regions, "Listen here's an assessment methodology. You can take this and use it for you permit decisions, because your problem setting is identical operationally to that of the in-house task group doing site designations." You're taking specific wastes on specific sites and you're asked to estimate the impact. It's the same question. So you can say, "Look, take this protocol, implement it at Level I, Level II, or III, whatever you think you need given the nature of the problem, the presence or absence of contaminants, so on and so forth." Use it for the permit process if you want. That's something we need policy guidance on. Perhaps the policy group here in this workshop can give us some recommendations. I don't think any final resolutions in terms of that policy are going to come out of this workshop. I think people like Pat Tobin, Steve Schimmel, Eric Eidsness and others, possibly in conjunction with their counterparts in the Corps, have to make decisions like that. As I stated several times, if we get hung up on policy issues like that, and trying to make recommendations like that I don't believe we'll accomplish the technical objective of developing a tiered assessment methodology. I think that if we get nothing else out of this workshop, we need to extend our best efforts towards developing such a methodology. Its implementation is a policy issue.

5. THURSDAY MORNING SESSION: ORAL SUMMARIES OF TASK GROUP FINDINGS

5.1 Group I: Exposure Assessment Methodologies

Reporter: Thomas P. O'Connor

What we did was to modify the protocol. In terms of site designation, we want to know the sites dispersal characteristics. We assume that effects of dredged material at the dump site are of no consequence. I think everyone can make that assumption, and it is only away from the dump site that one has to be concerned with concentrations. If, in fact, that's really the philosophy we're operating on, then instead of designating sites that one picked on some historical basis, one could actually choose a site. That's one advantage. I noticed this in one reading I made of the policy group's report. You really may want to disperse dredged material, and if you want to do that, you choose a site with that in mind. You don't pick a site that happens to be chosen for some historical arbitrary reason. If you want to disperse it you work from that. Well, whether you want to do that or not, you do have to go through dispersion equations like those that are included in the protocol. The hardest piece of information to get in terms of the dispersal characteristics, is the current at the bottom of the dump site. You can't go look that information up anywhere, and it is hard to measure it. Putting a current meter down for a week and a half to give you information will put you in a position of less value than if you hadn't put that current meter down. A week's worth of data can be very, very misleading. On the other hand, you don't want to spend half a million dollars to describe the current field in great detail, if the stuff you'll dump is of no great concern, or if, in fact, you'll never really use the site after it's been designated. So how does one get around this problem of knowing you need to have current information, and knowing it is very expensive, and perhaps not worth having after you've measured it? Well, we didn't go into a whole lot of detail on that, there's a couple of words to that effect, but what we'd like to have in the protocol are some guidelines for people who have to go through this exercise, as to where to go to get some estimate of what the currents are at the bottom at the dump site, and also where the currents are heading. You're not usually going to find that data in the literature. The tidal data you can find, the wind fields you can find. That's not a problem. What you need to do is ask around. You could go to the local fishermen, a local oceanographic center. Just get some feel for how the bottom currents behave in the area, and use that as the first order of approximation in this protocol and see where it leads. Do some sensitivity analysis of the results. That's your first order estimation of the dispersion field around the dump site. That first order of estimation will tell you a few things, like whether you expect the stuff to stay there at all. Maybe you want the stuff to stay there. I don't think you want it to, but that's policy. We don't deal in policy. So that's where our tiering comes in, it's in getting the ocean current. It's not in how you handle the data, it's how you get the inputs to the equations.

We also have some modifications of the protocol in terms of explicitly including storm events. The protocol methods presently underestimate the effects of the current, and we changed the dispersion equation in the latter part of Stage 3 in two ways. One, there's really no good reason to expect small scale dispersion to be different from one site to another, so we used the number 1 meter squared per second, and let that apply regardless of where the site is. Two, we've modified that equation to include the settling term, because that is what's going to happen to dredged material. The flux of sediments from these sites is episodic. The stuff gets picked up during high energy events and moved downstream, wherever downstream is, and as the energy subsides, that stuff settles and begins another resuspension-settling cycle. That's it. It's simple to talk about, but hard to do because the data isn't always available.

5.2 Group II: Hazard Assessment (Exposure Sub-Group)
Reporter: Dominic M. DiToro

After the hydrodynamicists gets through with the easiest part of the problem - which is telling us which way the water goes it devolves upon the Exposure Assessment Group to take the concentrations of materials that are calculated by the transport models and make something sensible out of it. After Tuesday night's meeting, we reassembled the group on Wednesday morning and considered again the comments that were made by the assembled group, and we decided that the major modification that was required in tier one was to rename it, and call it a maximal upper bound calculation, or maximal exposure calculation. And we did one other thing. If you remember, that was based on some pretty crude assumptions which were attempts to get exposures which could be no higher. We thought that perhaps we had solved a non-problem, namely that no material would ever pass through tier one and not have to be considered again. No site would ever be judged acceptable on these very, very conservative assumptions. So we took some numbers, and we tried out the calculations and it turns out that indeed the tier one calculation screens very nicely with certain fairly clean dredge materials. In other words, even under the most conservative assumptions that were made under tier one, you can say that there will be no deleterious effects for the use of certain sites. Some fairly contaminated materials, did not pass the rules we had set down, and therefore, one would have to go to tier two.

A major problem with exposure assessment is computing the available fraction. So the major thrust in tier two was to suggest methods of measuring the available fraction at least chemically. We suggested that desorbtion tests have to be made on the waste in order to do the calculations correctly. We suggested that sediment bioassays have to run in order to compensate for the fact that we don't have any sediment quality criteria. We basically set up four analysis modes that have to be gone through, which are the four exposure pathways that exist: the initial dump, which appears to be a non-problem in most instances; the storm resuspension exposure where you might pick the whole annual deposition and suspend it up into the overlying water, get desorption from the particles, and get water exposure via that route; the quiescent leaching from quiescent sediments; and finally, the contamination of the sediments themselves as the material gets dispersed out beyond the dump site. Each of those exposure routes is addressed in detail. We recommend that certain modeling frameworks be put together to refine, particularly, the resuspension calculations, and our inability to compute at least roughly what food chain transport does. This fifth exposure route, which is fish eating contaminated benthic organisms has to be evaluated at least order-of-magnitude. Once you've done that, I think you're in pretty good shape. The problem is that no one has really road tested any of this - not even physical models - but the chemical models as well. We made a strong recommendation that these methods, if they're going to be used seriously, that is to say if decisions are going to be based on these procedures, that these models be field tested in a serious, comprehensive way.

We supported the use of the water quality criteria as what you do in the water column to decide impact. We strongly suggested that we think about the sediment-quality criteria, and we strongly supported the use of bioassays as essentially being the only game in town.

5.3 Group III: Hazard Assessment (Effects Sub-Group)
Reporter: John H. Gentile

We basically abolished the idea of tiers. Let's just talk about some processes. The first thing in the biological area that was necessary was taking a site, any site, anywhere, and go through a process of describing the critical habitats and the resource populations at risk in that area. It was the feeling of the group that we also should have some baseline information on what the benthic community structure looks like. Now, if you're in a historical site, we might even add to that piece of information if it's available, some gradient analyses of the communities and some gradient analyses of the residual. But that's basic kinds of information you have to know about biological community in this proposed area. Given that, you now have a waste, you need to have some kind of chemical characterization. Then we rely on the first two groups to give us some exposure fields. Now, the way it's set up if we have exposure fields that overlap with critical communities, of course you're in a situation where you can make a decision fairly straight forward. If you're not, and essentially you've got exposure fields and the local benthic community, we then come into what Dominic was talking about - tier one - what his tier one calculations were. We talked about the water quality criteria forming that basis. We talked to him a little about a similar kind of exercise in the sediments, assuming all the material is released. But that was how we were looking at what he was calling tier one. After we moved out of that, we were into a data-gathering effort which more closely relates biological responses to dissolved components, the suspended particulate contaminants, and the sediments, solid-base contaminent, 2 - for the water short-term biological effects, sediments long-term chronic, also residue values.

I guess our recommendations were basically some of the following. There is a need to develop some kind of sediment toxicity criteria of some type. We need to start looking to develop data bases that allow us to have that kind of information. We need to develop some similar kinds of information on the bioavailability, but particularly the bioaccumulation of residues from contaminated particulates, suspended particulates, or in the sediment phase. We also felt we had to put some effort into making some approximation of the effects of body burdens. What does it mean to a species? What does it mean to any endpoint you choose to look at. If you've a residue, can you link it to anything? For some of these methodologies we ought to field verify them, at some level. Otherwise we're really flying blind. There is an EPA/COE Interagency Committee to rewrite an implementation manual, and we felt that it would be certainly worthwhile recommendation if those guys become active and start to look at the problems outlined in this workshop. Sticking with the process, if we were to use the interim disposal action we felt there had to be a monitoring program in place. We felt kind of uncomfortable with the discretion for monitoring being left up to the discretion of an individual region, and we felt that it would be filled in at some other point. And in that monitoring program we have some of the components that we have in the earlier phase. We need to look at some communities, there are some seven toxicity-type tests one can do. They're not applicable in all cases - as a matter of fact they'd be applicable in only certain cases, but basically that's how we saw it: the front end with the characterization of habitats and some tier one upper boundary calculations, a second section where we're actually taking the improved exposure models with partitioning to give a better sense of what's happening. We need some actual measurements of sediment toxicity so that we can go from something like three to four orders of magnitude of uncertainty down to two or three. But it's very crude. Rick and I were just talking about sediment toxicity tests where we've probably got a range of two orders of magnitude depending on the organic carbon in the sediment, in terms of a heavy metal type toxicity test. So we're in the area of two to three orders of magnitude range, something like that. That's just a general summary.

5.4 Group IV: Policy Issues

Reporters: Douglas Lipka and Michael G. Norton

Doug Lipka: O.K., I'll just say a few words and then I'd like to turn it over to Mike Norton who's done most of the writing. Really, we have not had the appropriate mix of people to deal with policy. Most of us had a problem with that. More appropriately, we would rather designate ourselves as the Common Sense Group, which is very different from policy. We did struggle with terms of reference for three or four days, and finally I think some things did come through yesterday. Mike is mainly responsible for getting things down, but what we did say was that this whole site designation process is a continuum. There are some artificial boundaries which we are not able to determine. Someone is going to have to determine them. We'd like to make some recommendations.

Mike Norton: Doug has already said that we struggled most of the time with trying to get our terms of a reference right. How should we regard the site designation process in the scheme of approval, which starts with a blank area of ocean on the map, in which you have to select potential candidate sites, which you might submit to the site designation or the specific permit process? You then move forward with a candidate site or candidate sites through the site designation stage. Having got there, you then have a specific permit evaluation which looks at all the aspects of the site and the waste in detail, and even then you are not finished because then you move on to what we would call dump site management, where you are looking at field studies to actually determine the extent of effects of dumping. So with that continuum, starting from scratch to the actual operation of dumping somewhere you have to fit in what you call dumpsite designation. Having tried to get that clear in our minds, we then looked at the protocol that was drafted, and we concluded pretty easily that the protocol included methods that really were appropriate to the middle two stages of the dump site designation and also to the special permit application and evaluation. We tried then to look through the draft protocol to apply this relatively consistent philosophy to the various stages of the protocol. We came up with some conclusions. If you attempted to carry out the sort of quantitative assessment that was in many parts of the protocol at the site designation stage, you be doing would be one of two things. You would either be running up against basic defficiencies because you didn't have the data. For instance, you might lack detailed composition of the waste. If you had that data, you would be essentially duplicating special permitting procedures. So we came to the conlusion that the site designation stage would be better regarded as a precursor to the special permit stage, and not as a separate intensive activity. I know that's not what the regulations say but we didn't wish necessarily to be bounded by the existing regulations. So with that in mind, we went through and we provided some general, specific principles which we thought should apply. The first of these general principles was essentially to try to use the data that was available as far as you could, but at the same time make an intelligent estimate of how far wrong you might be: You should do this consistently throughout the protocol. You shouldn't allow yourself to be beguiled by the fact that you put down three significant figures. You should always remember that there's plus or minus seventy percent on it.

Secondly, we thought that another general principle should be that when you're making estimates which might be based on composition of the waste or the current in the area, you should always try to be conservative, but you should also equally try to be realistic. We didn't see much attractiveness in a course that caused everything to fail at first assessment, which means we'll all end up on Tier 101. And we're glad to hear that Dominic DiToro's Tier one now complies with this policy group regulation. Let me congratulate him on the sensing our thoughts across 200 yards of campus. I'll run through very quickly the other guiding principles although I won't spend much time on them. Firstly, the existing protocol does presume to be rather silent on methods of selecting candidate sites, so we did spend some time discussing how you get from zero to that point. We drafted a two-page preamble which you might wish to consider, which essentially in our group lays out the steps that would have been taken in order to get to a candidate site. We think that stage one would need amendment in the light of that.

Secondly, in stage two, which deals with the waste, - you would probably have a generic waste which, in some cases, you might have some good data. But in the case of the generic waste you should probably base your assumptions on the most probable waste. Stages three and four, we didn't really see why you had two stages there, because they seem to be just essentially the physical transport model of the sea bed and in the water column. We thought here we were trying to estimate what happened to the waste when it is being dumped and where it goes afterwards. I don't think we've really got much to add there except that our emphasis would be to try to use what data were available. Recognizing that you may have to go out and do one or two current measurements if there's a complete blank on the map, the emphasis should be on trying to get the data from existing sources.

We talked about resuspension phenomena and transport of contaminants from the solid-to-liquid phase and such matters. We thought emphasis should be given to using literature or other site specific information which appeared relevent. We thought it inappropriate at the site designation stage to pursue field studies. That type of activity should be related to or reserved for the special permitting process. We also thought there were some fundamental limitations on how far you would really want to push the quantitiative nature of this assessment, and although the formulae look very elegant, and you can in theory get useful results, one does come up against some basic limitations on the precision of the evaluation, such as inability to model the behavior of cohesive sediment. Therefore we thought that certainly at this stage you should not try and beat your head against that particular wall, and get absolute accuracy at great expense. Now at stage five, we come to the tricky thing. We have to decide whether we thought water quality criteria were an appropriate end point, and I'm afraid we decided it wasn't an appropriate endpoint for this stage of the assessment. The reasons for this are numerous and we tried to skirt around, making a judgement of the water quality criteria, themselves. At this stage there would be some imprecision on the waste composition. We would certainly not know enough about the partitioning between solid phases and solid phases suspension, etc., and we would also not be able to tackle the complex nature of chemical speciation. We thought it was probably inappropriate to use the water quality criteria until you had some information on these factors. We prefer to do the roughing approach, using, if available, specific waste bioassay data or, if not available, some realistic estimate of what that generic waste might have in the way of toxicity, and to make some assessments on that basis. Stage 6, hypoxic events, we thought to be so unusual they should not be a major part of the protocol. It should only be required where there's some indication that the area could be potentially sensitive to this. That brings us finally to stage 7 which we thought was a bit back-to-front in terms of priorities. We recognize that we were trying to estimate the impact of the exposure fields on the living resources, but we thought that this stage the site designation stage, we should not necessarily be counting worms, we should be looking for potential impacts, on commercial species, protected endangered species, and looking both from the point of view of toxic impact and also potential effects on their consumer quality. The benthic characterizations were, we thought, again, more appropriate to the special permit stage. Finally, in a synthesis at the end of the assessment, one should bring together the results of this sensitivity analysis or consideration of errors which are applied throughout, and try and identify the key assumptions, the key predictions, the key factors which really were influential in the final decision about the site designation. These specific things can then be easily identified and addressed in detail at the special permit evaluation stage.

Vic Bierman - I'd like to make one comment on the report just given by the policy group. It was the initial intent to ask the policy group to address issues which were related primarily to the protocol and consider charges specified in the handout, things like historical versus alternative sites, implementation of protocol, and things like that. I think that it became clear early on in the workshop that that was a difficult objective to accomplish because the terms of reference, in the sense that site designation was not well distinguished from the permitting process, and that we had this continum and that the boundary was not well drawn. I think that became a major policy issue to be resolved. I commend the policy group for their efforts toward that end, and for their specific recommendations in trying to resolve that continuum into a number of well-defined operational steps and to attempt to develop some recommendations regarding the level of intensity, the level of data gathering, and the level of assessment, that perhaps one might want to consider for each of these steps. I think that those recommendations constitute, to the best of my knowledge, the first time that the Office of Water will have received guidance in that form regarding the boundaries. It's a very difficult problem. Just as Mike started to speak I refreshed my memory on the eleven criteria that one must consider in site designation. To my way of thinking, those criteria are sufficiently broad that one may interpret them in just about any sense one wishes. I could understand that one could look at those criteria and interpret the site designation process as simply a data exercise. On the other hand, I think they could legitimately be interpreted as demanding some level of assessment beyond the data gathering phase. Those are the terms of reference, the regulatory terms of reference. I'm afraid that we just haven't taken the step beyond that to develop a specific policy guidance for implementating those regulations. Hopefully, that's one of the things that will come out this workshop. Hopefully those policy decisions will be made by EPA or the Corps and we can go about the business then of developing a final protocol and decide how it's to be implemented. So, in short, thank you to the policy group. It was a difficult task and, I think, well done.

Doug Lipka - I think what we have here are the tools to be developed in the protocol for dumpsite designation. By using some of these tools, you can get an evaluation on whether a site is appropriate or not. We discussed in the policy group how we see the site process as primarily a means for determining the boundaries of the site, and that's very significant. In fact that's major progress in the site designation process.

Vic Bierman - For the first time that I am aware, and I think this is the part that is exciting, you have exposure people sitting down with effects people and we're attempting to address the issue of how to synthesize exposure and effects information, on the same spatial scales, at compatible temporal scales, in the same environmental compartments, with the criteria and the exposure fields being cross-linked, rather than having the exposure boys go off and do models, and the effects boys go off and develop criteria, and then the person who's got to use the two has no idea how to interpret them individually much less how to overlay and synthesize them. That, I think is the most important single technical result that's come out of this workshop.

A couple of other points. I commend strongly the suggestions to attempt validation of this protocol on existing data to find out whether it's sensible in terms of what we already know. Second, I commend the notion of recommending monitoring so that, if this methodology is used, in the permit mode, if a waste is to be dumped we could get out there and actually measure effects. The monitoring program ought to be well specified in terms of the assessment that's used to issue a permit. You do a Tier one assessment, certain things are predicted, and you'd certainly better make sure that you measure those things. If the assessment's at Tier two, the monitoring ought to be at the Tier two level, so you have data, not just monitoring data, but data that's compatible with the very predictions you made and the parameters that were involved in these calculations.

As to just what's going to happen with proceedings and if, in fact, we're going to synthesize the protocol into some form of operational document. It's up to the chairmen to work with their individual groups, and what I'd like to do is ask the task group chairmen to remain briefly after the general meeting so we can discuss some of the mechanics of getting from your reports as they are in their present form to some type of final report. I would ask those of you - the individual task group members - I would ask you to work with your task group chairmen in developing your final reports. If you have any questions or comments regarding the discussion, anything that went on outside the task groups that should appear in the task group report, you can contact me by phone or in writing.

Beyond that, as I said Tuesday night, this was a good group. I appreciate your efforts. You've worked sincerely and hard. Thank you very much for coming and working so diligently. Personally, I really hope that individually as well as collectively, we may have the opportunity to work again. Many of you were new to me, and I've enjoyed working with you. I hope that the personal contacts and relationships that were made here will continue in the future. Thank you.

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